ESL-TR-12-04-01

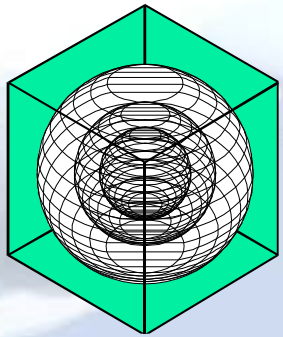
QUANTIFICATION OF ENERGY AND EMISSIONS SAVED IN ENERGY EFFICIENCY/RENEWABLE ENERGY (EE/RE) PROGRAMS IN TEXAS

April 2012

Jeff S.Haberl

Energy Systems Laboratory

Texas A&M University



ACKNOWLEDGEMENTS

Faculty/Staff: Bahman Yazdani, Juan-Carlos Baltazar, Jaya Mukhopadhyay, Hyojin Kim, Shirley Ellis, Gali Zilbershtein, Patrick Parker, Larry Degelman, Vic Reid, Stephen O'Neal.

Students: Simge Andolsun, Kee Han Kim, Sung Lok Do, Chunliu Mao.

ACKNOWLEDGEMENTS

Faculty/Staff: Bahman Yazdani, Juan-Carlos Baltazar, Jaya Mukhopadhyay, Hyojin Kim, Shirley Ellis, Gali Zilbershtein, Patrick Parker, Larry Degelman, Vic Reid, Stephen O'Neal.

Students: Simge Andolsun, Kee Han Kim, Sung Lok Do, Chunliu Mao.

TCEQ: Vince Meiller, Theresa Pella.

TPUC: Theresa Gross, Jess Totten

SECO: Dub Taylor, Felix Lopez

ERCOT: Warren Lasher

USEPA: James Yarbrough, Denise Mulholland, Art Diem, Julie Rosenberg.

Energy Systems Laboratory

Faculty Members – 6

David E. Claridge, Director, MEEN
Charles H. Culp, Associate Director, ARCH
Jeff. S. Haberl, Associate Director, ARCH
Michael Pate, Associate Director, MEEN
Dennis O'Neal, Associate Director, MEEN
Bryan Rasmussen, Associate Director, MEEN

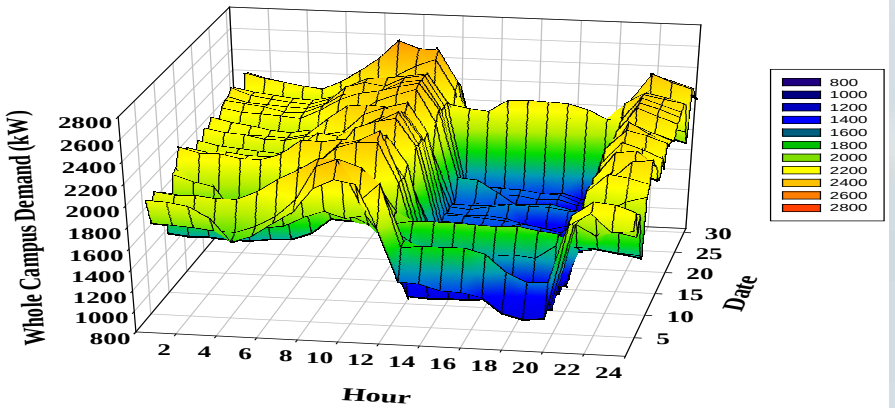
Full-time Staff & Engineers – 51

Undergrad / Graduate Students – 88

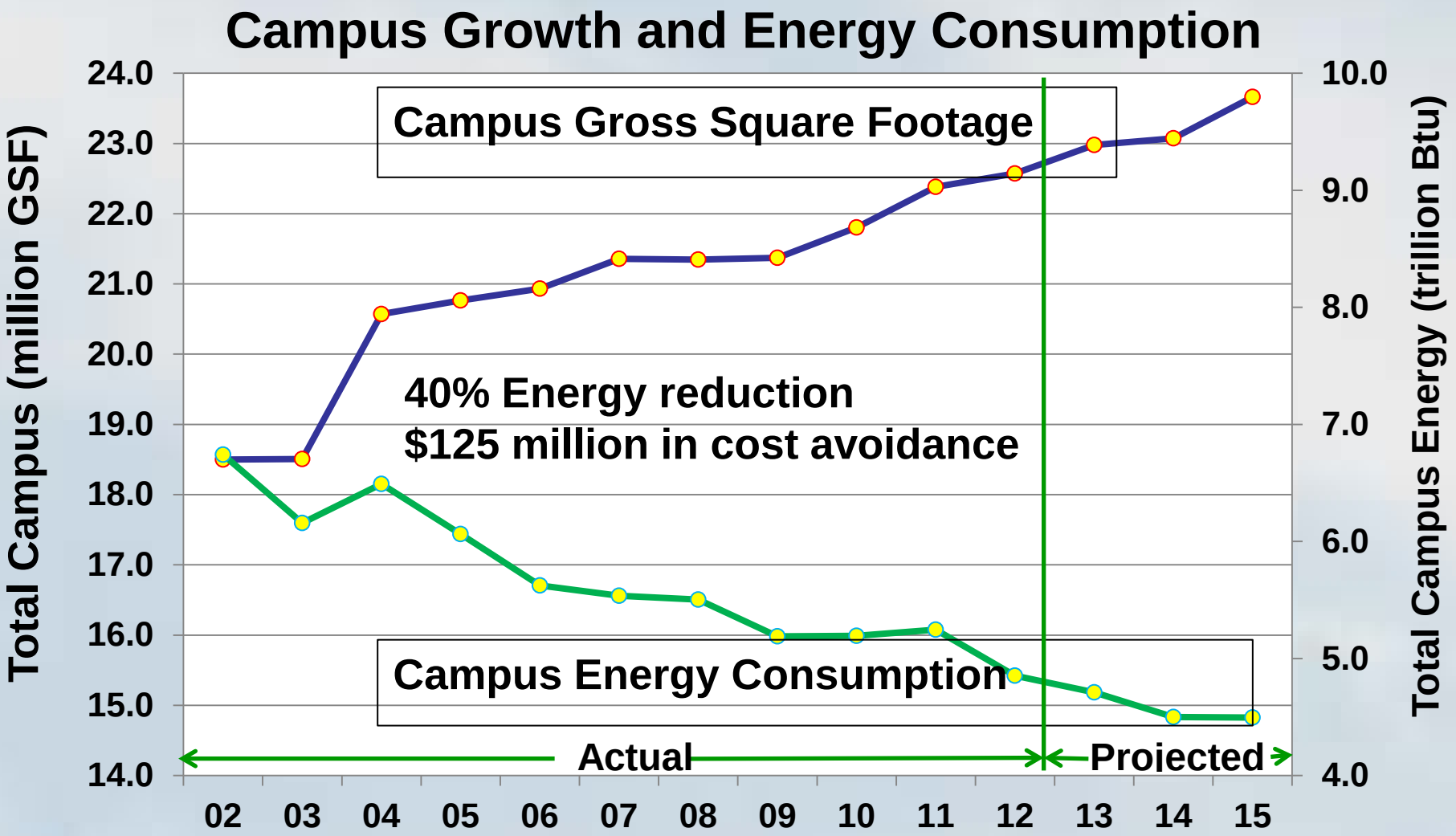
Budget - $14.9 million in FY2011

CONTINUOUS COMMISSIONING ®

- Existing Buildings and Central Plants
  - Energy savings analysis

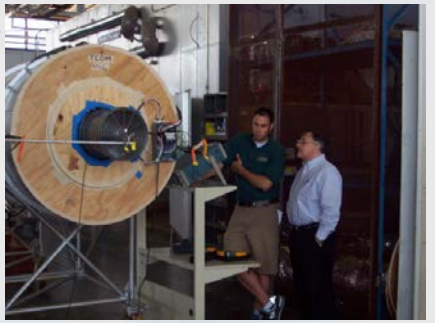


CONTINUOUS COMMISSIONING ®



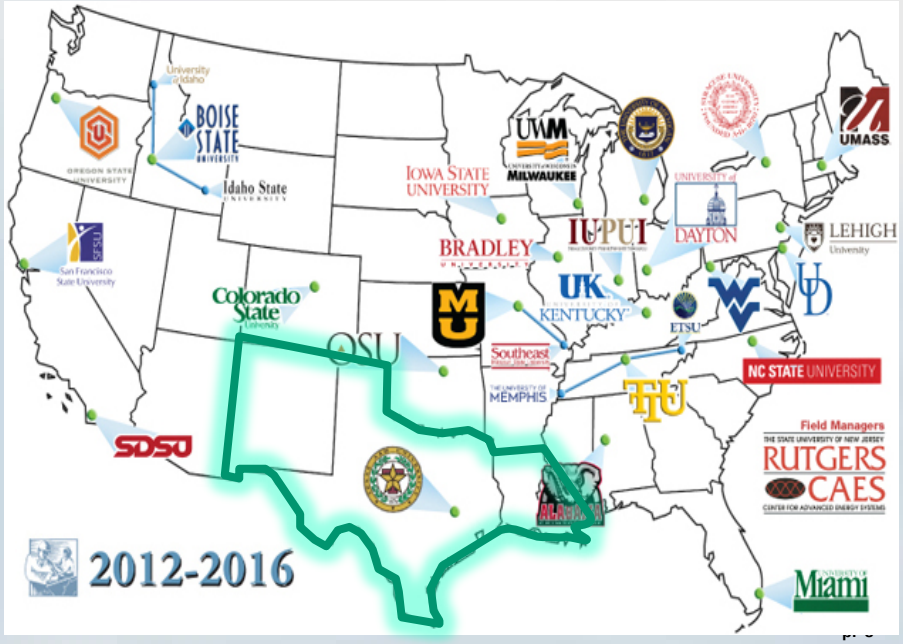
RIVERSIDE ENERGY EFFICIENCY LAB

- Fan Testing / Certification
- Calibration Lab
  - Flow, electrical, temperature, humidity meters
- Psychrometric Chambers
  - A.C. and heat pump testing
- Acoustic Testing
- Duct Pressure Loss
- Enthalpy Rec. / Mem.Dehumid.
- Solar Test Facility



INDUSTRIAL ASSESSMENT CENTER

- Opened in 1986
- Accomplishments
  - Received numerous awards from DOE
  - Educated 200+ students, Performed 600+ assessments
- Impact
  - $60M per year in savings
  - $800M cumulative savings



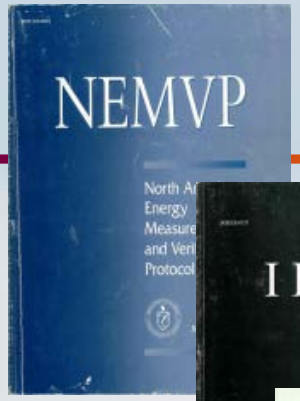
INDUSTRIAL ASSESSMENT CENTER

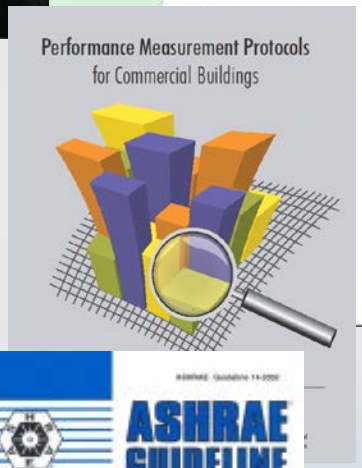
- Sponsored by the US Dept. of Energy
- No-cost energy assessments
  - Sales under $100 M
  - Fewer than 500 employees
  - Utility bills over $100K
  - Facility missing in-house skills

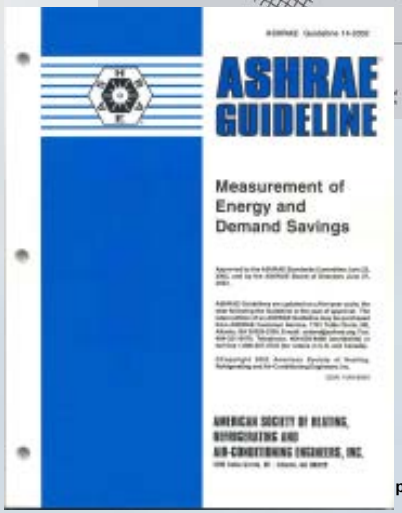
- Student Training
  - Identify measures
  - Data collection, Reporting

- Bryan Rasmussen, Director
- Jim Eggebrecht, Asst.Director

ESL PUBLICATIONS







- Journal / Proceedings / Papers
  - Over 1,500
  - In major international journals and ASHRAE publications
- Led / Participated
  - NEMVP, IPMVP – International Performance Measurements and Verification Protocol
  - ASHRAE – Guideline 14, Measurement of Energy and Demand Savings
  - ASHRAE – Guideline 1.2, Commissioning
  - ASHRAE – PMP
  - ASHRAE – Standard 140

ESL CONFERENCES

- ICEBO
  - International Conference on Enhanced Building Operation
- CATEE
  - Clean Air Through Energy Efficiency
- IETC
  - Industrial Energy Technology Conference
- H&H
  - Hot and Humid

LEGISLATURE DIRECTED RESEARCH

- Texas Emission Reduction Plan (TERP)
  - Emissions reductions in Texas counties
  - Energy efficiency codes support and training

Houston: Clear day vs. Ozone day

LEGISLATIVE RESPONSE

Legislation passed to reduce energy/emissions

Senate Bill 5 (77th Legislature, 2001)

Ch. 386. Texas Emissions Reduction Plan

Sec. 386.205. Evaluation Of State Energy Efficiency Programs (with PUC)

Ch. 388. Texas Building Energy Performance Standards

Sec. 388.003. Adoption Of Building Energy Efficiency Performance Standards.

Sec. 388.004. Enforcement Of Energy Standards Outside Of Municipality.

Sec. 388.007. Distribution Of Information And Technical Assistance.

Sec. 388.008. Development Of Home Energy Ratings.

TERP Amended (78th Legislature, 2003)

Ch. 388. Texas Building Energy Performance Standards

(HB 1365) Sec. 388.004. Enforcement Of Energy Standards Outside Of Municipality.

(HB 1365) Sec. 388.009. Energy-Efficient Building Program.

Ch. 388. Texas Building Energy Performance Standards

(HB 3235) Sec. 388.009. Certification of Municipal Inspectors.

TERP Amended (79th Legislature, 2005)

Ch. 382. Health and Safety Code

(HB 2129) Sec. 386.056 Development of Creditable Statewide emissions from wind and other renewables.

(HB 965) Sec. 382.0275 Commission Action Relating to Water Heaters

TERP Amended (80th Legislature, 2007)

Ch. 382. Health and Safety Code

(HB 3693) Sec. 388.003 added subsection (b-1), (b-2), (b-3) that allows SECO to adopt new editions of the IECC based on written recommendations from the Laboratory.

(HB 3693) Sec. 388.008 Development of Standardized report formats for newly constructed residences.

Ch. 386.252 Health and and Safety Code

(SB 12) Section 388.03 added subsection (b-1), (b-2) allows SECO to adopt new editions of the IECC based on written recommendations from the Laboratory.

TERP Amended (81st Legislature, 2009)

Ch. 382. Health and Safety Code

(HB 1796) Section 23 amends Sec. 386.252 (a) and (b) extends date of TERP to 2019 and requires Commission to contract with Laboratory for creditable EE/RE emissions reductions.

TERP Amended (82nd Legislature, 2011)

Ch. 477.004 Health and Safety Code

HB 51 Section 2, b-2, establishes advisory committee, which including the Laboratory

Section 3 & 4 amends review of municipal's amendments.

Ch. 388.003e & 388.007c,d Health and Safety Code

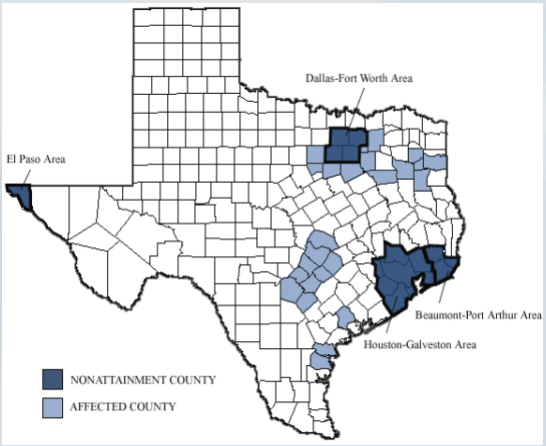
HB 51 Section 3 & 4 amends review of municipal's amendments.

Ch. 388.006 Health and Safety Code

SB 898 Section 2, requires the Laboratory to calculate energy savings and emissions reductions for political subdivisions reporting to SECO.

Ch. 39.9051 Utilities Code

SB 924 Section 1g,h and Section 2c,d requires the Laboratory to calculate energy savings and emissions reductions for political subdivisions reporting to SECO.



ACTIVITIES FOR TERP

Calculate Emissions Reduction

- Code Compliant Construction
- PUC, SB5, SB7 Program
- Renewables
- Other Energy Efficiency Programs

Code-Compliance Calculator

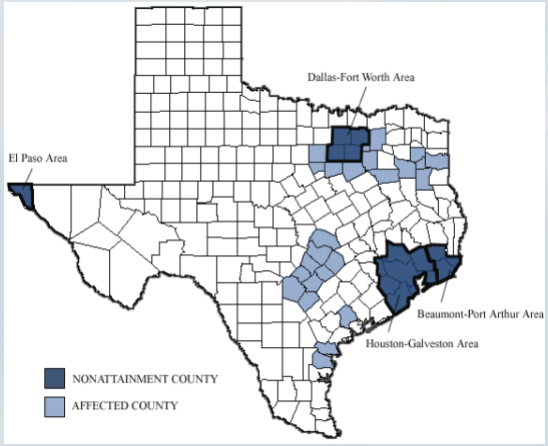
- Development, Certification
- Maintenance and Updates
- Technical Support
- Training

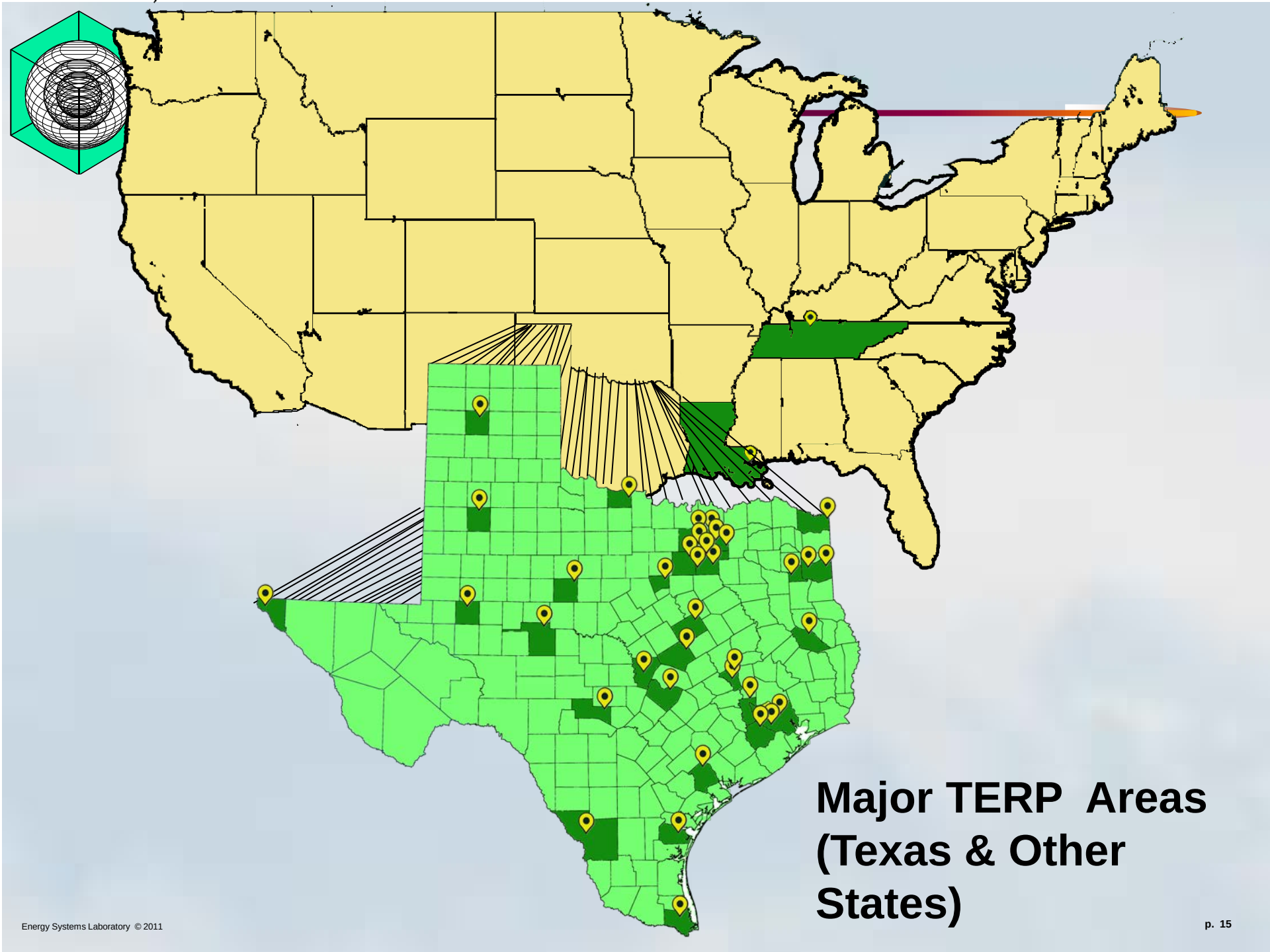
Technical Assistance

- Review New Energy Codes
- Evaluate and Quantify Above – Code Amendments
- Answer Energy Codes Questions

Training and Outreach

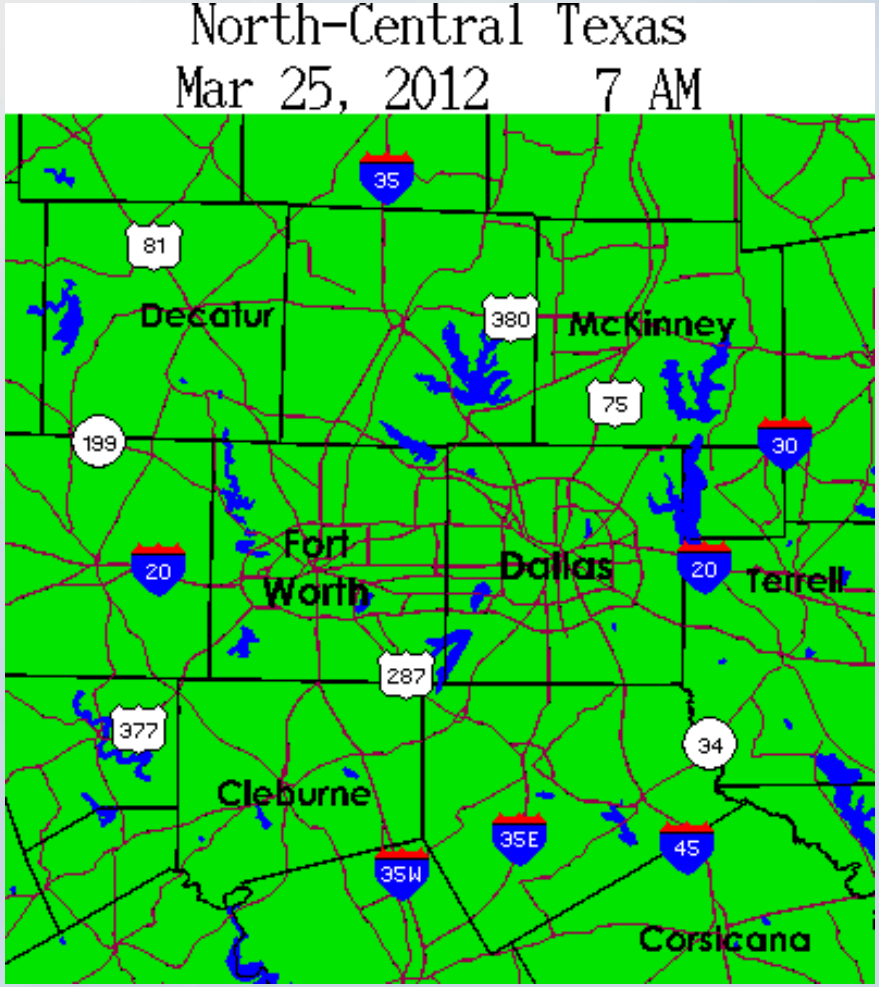
- Annual Conferences
- Code Training Workshops
- Website

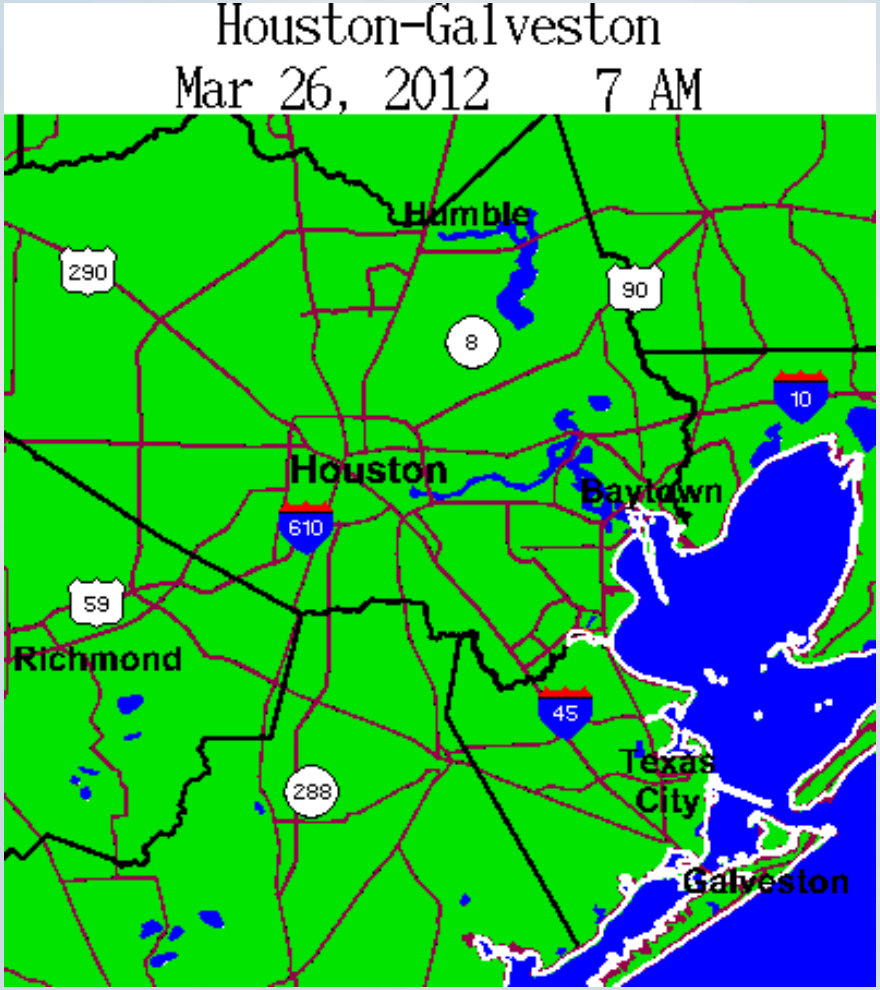




Major TERP Areas (Texas & Other States)

OZONE ALERTS – Why spatial & temporal?





EPA CRITERIA FOR SIP CREDITS

EPA GUIDANCE ON SIP CREDITS FROM EE/RE (2004)

- **Quantifiable:** The emission reductions generated by measures to reduce emissions must be quantifiable and include procedures to evaluate and verify over time the level of emission reductions actually achieved.

- **Surplus:** Emission reductions are surplus as long as they are not otherwise relied on to meet air quality attainment requirements in air quality programs related to your SIP.

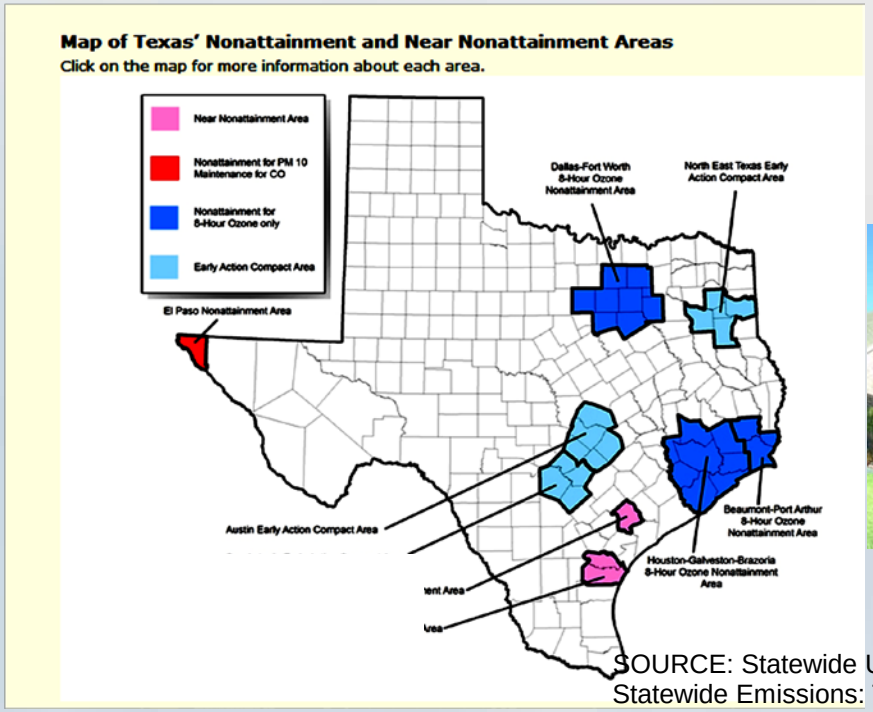
- **Enforceability:** Measures that reduce emissions from electricity generation may be: (1) Enforceable directly against a source; (2) Enforceable against another party responsible for the energy efficiency or renewable energy activity; or (3) Included under our *voluntary measures* policy.

- **Record Keeping:** The measure should be permanent throughout the term for which the credit is granted unless it is replaced by another measure or the State demonstrates in a SIP revision that the emission reductions from the measure are no longer needed to meet applicable requirements.

ENERGY EMISSIONS - IMPACT FACTOR

	Use	NOx	Upgrade Avg.Life	Impact Factor
Industries:	60%	23%	5 – 20 yr	1 – 5
Vehicles:	19%	54%	7 – 10 yr	4 – 5
Buildings:	21%	22%	25 – 50 yr	5 – 11

Buildings substantially impact emissions!



SOURCE: Statewide Use: USDOE/EIA, 1999
Statewide Emissions: TCEQ 2009

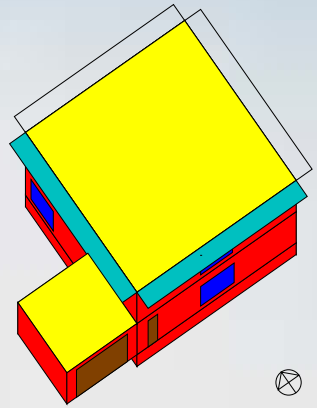
IECC CODE SF, MF SAVINGS

Quantify the reduction of NOx emissions due to the implementation of 2000 IECC with 2001 Supplement for new residential construction:

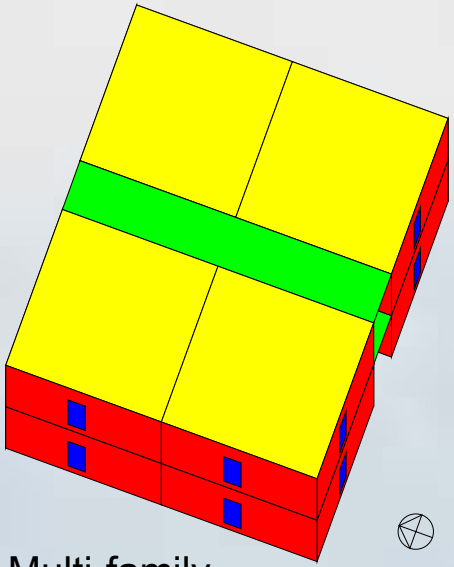
IECC CODE SF, MF SAVINGS

Quantify the reduction of NOx emissions due to the implementation of 2000 IECC with 2001 Supplement for new residential construction:

- Prototype simulation models were created for both single and multifamily configurations using DOE-2.1e simulation software



Single-family



Multi-family

IECC CODE SF, MF SAVINGS

Quantify the reduction of NOx emissions due to the implementation of 2000 IECC with 2001 Supplement for new residential construction:

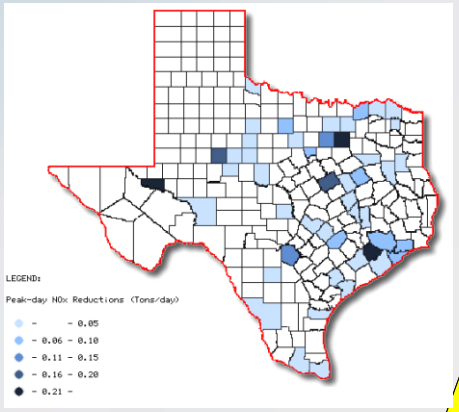
- Prototype simulation models were created for both single and multifamily configurations using DOE-2.1e simulation software
- The simulation models were then modified to accommodate the different scenarios for envelope and HVAC systems found typically in residences

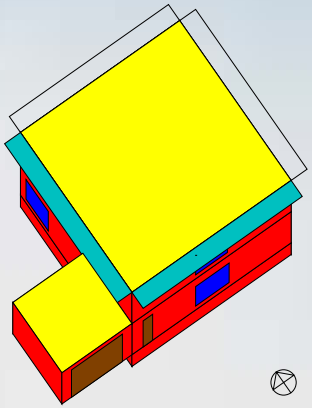
PARAMETER NO:	DESCRIPTION	DEFAULT	STATUS	COMMENT
LOADS				
b01	Quick or thermal mode (Q or T)	Quick (Q)	Fixed	Q simulates the building as massless, T will include thermal mass
b02	Location (county name)	Bastrop (BAS)	User Defined	41 counties linked to 9 TRY packed weather files according to climate zone
b03	Azimuth of building (degree)	0	User Defined	Orientation of the building
b04	Width of building (ft)	50	User Defined	
b05	Depth of building (ft)	50	User Defined	
b06	Height of wall (ft)	8	User Defined	
b07	Door height (ft)	6.67	Fixed	Value from survey of manufactured doors
b08	Door width (ft)	3	Fixed	Value from survey of manufactured doors
b09	Run year	2000	User Defined	
b10	Option of second floor (1 or 2)	one floor (1)	User Defined	Controls activation/deactivation of one and two story portions of the BDL input
b11	Activation/ Deactivation of crawl (C or S)	Slab (S)	User Defined	Controls activation/deactivation of crawl space and slab on grade floor types for the residence
b12	Height of crawl space wall above ground(ft)	1.5	User Defined	
b13	Height of crawl space wall under ground(ft)	1	User Defined	
c01	Roof outside emissivity	0.89	User Defined	c01 and c02 are used to define "Roof color"
c02	Roof absorptance	0.45	User Defined	
c03	Roof roughness	1	Fixed	This is used to calculate the outside film coefficient for heat transfer calculations, DOE-2 allows values from 1 to 6 increasing in smoothness
c04	Roof R-value (Hr-sq.ft-F/Btu)	R-26	User Defined	
c05	Wall absorptance	0.57	User Defined	c05 and c07 are used to define "wall color"
c06	Wall roughness	2	Fixed	This is used to calculate the outside film coefficient for heat transfer calculations, DOE-2 allows values from 1 to 6 increasing in smoothness
c07	Wall outside emissivity	0.9	User Defined	c05 and c07 are used to define "wall color"
c08	Wall R-value (Hr-sq.ft-F/Btu)	R-13	User Defined	
c09	Ground reflectance	0.24	Fixed	This defines the fraction of sunlight reflected from the ground
c10	Window option (S or D)	Same (S)	User Defined	Controls the input of same or different windows on individual orientation of the house
c11	U-Factor of glazing (Btu/hr-sq.ft-F)	0.75	User Defined	
c12	Solar Heat Gain Coefficient(SHGC)	0.4	User Defined	
c13	Number of panes of glazing	2	Fixed	
c14	Frame absorptance of glazing	0.7	Fixed	
c15	Frame type - A,B,C,D,E	Aluminium w/o thermal break (A)	User Defined	Allows user to select from 5 different frame types
c16		Void		
c17	Floor weight (lb/sq-ft)	11.5	Fixed	Value from IECC 2000
c18		Void		
c19	R-value of concrete slab (hr-sq.ft-F/Btu)	0.44	Fixed	
c20	Air film resistance (hr-sq.ft-F/Btu)	0.77	Fixed	
c21	Percentage of window area (%) for whole area or front side wall	15	User Defined	
c22	Percentage of window area (%) for back side wall	15	User Defined	
c23	Percentage of window area (%) for right side wall	15	User Defined	
c24	Percentage of window area (%) for left side wall	15	User Defined	
c25	Percentage of window area (%) for 2nd floor left side wall	15	User Defined	
c26	Floor R-Value (hr-sq.ft-F/Btu)	11	User Defined	
c27	Crawl space wall R-value (hr-sq.ft-F/Btu)	R-5 (F)	User Defined	Allows user to select from 13 different insulations
c28	Slab perimeter R-value and depth	R-0 (A)	User Defined	Allows user to select from 11 different insulation R-values and depths
sp01	Number of people	2	User Defined	
sp02	Number of bedroom	1	User Defined	
s01	Front eave shade (ft)	0	User Defined	
s02	Back eave shade (ft)	0	User Defined	
s03	Left eave shade (ft)	0	User Defined	
s04	Right eave shade (ft)	0	User Defined	
SYSTEM				
sy01	Mode of system: 1, 2, 3	Gas/Electric (1)	User Defined	Allows user to select all-electric, gas/electric or heatpump for HVAC
sy02	Cooling Capacity of cooling system (Btu/hr)	0	Fixed	DOE-2 is autosizing the system
sy03	Heating Capacity of heating system (Btu/hr)	0	Fixed	DOE-2 is autosizing the system
sy04	Seasonal Energy Efficiency Ratio (SEER)	10	User Defined	
sy05	ANNUAL FUEL UTILIZATION EFFICIENCY (AFUE)	0.8	User Defined	
sy06	HEATING SEASONAL PERFORMANCE FACTOR (HSPF)	6.8	User Defined	
sy07	The number of pilot lights of DHW	0	User Defined	
sy08	The number of pilot lights of Furnace	0	User Defined	
sy09	The number of pilot lights of others	0	User Defined	
sy10	Switch for Energy Factor for Domestic Hot Water consumption	Autosized (A)	User Defined	Allows user to input a DHW or let DOE-2 calculate the size and efficiency of the DHW
sy11	Energy Factor (%) for Domestic Hot Water	54	User Defined	Only applicable if the user chooses sy10 = S (EF is user defined)

IECC CODE SF, MF SAVINGS

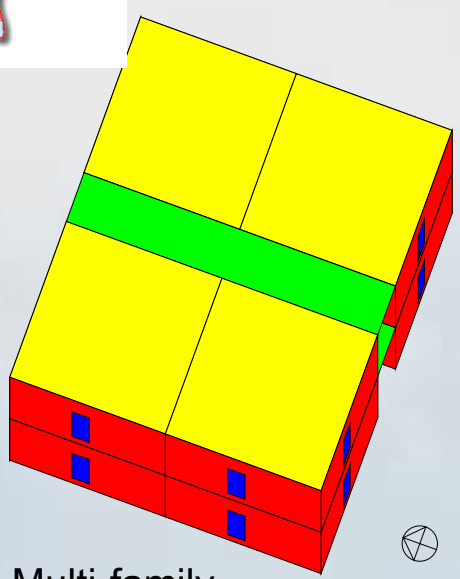
Quantify the reduction of NOx emissions due to the implementation of 2000 IECC with 2001 Supplement for new residential construction:

- Prototype simulation models were created for both single and multifamily configurations using DOE-2.1e simulation software
- The simulation models were then modified to accommodate the different scenarios for envelope and HVAC systems found typically in residences
- These simulation models were then linked to a web-based graphic user interface and US-EPA's eGRID to convert the energy savings to NOx emissions reduction





Single-family

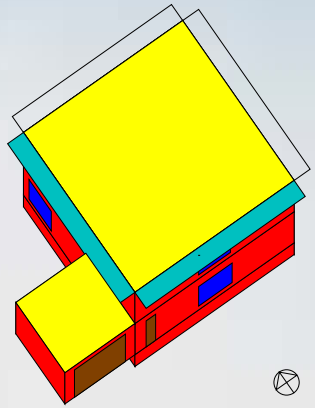


Multi-family

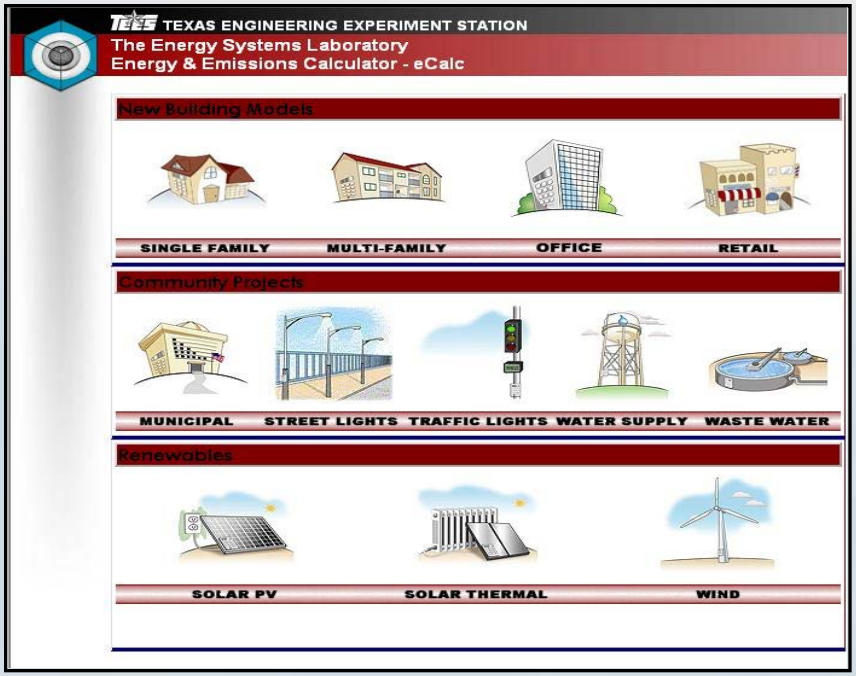
IECC CODE SF, MF SAVINGS

Quantify the reduction of NOx emissions due to the implementation of 2000 IECC with 2001 Supplement for new residential construction:

- Prototype simulation models were created for both single and multifamily configurations using DOE-2.1e simulation software
- The simulation models were then modified to accommodate the different scenarios for envelope and HVAC systems found typically in residences
- These simulation models were then linked to a web-based graphic user interface and US-EPA's eGRID to convert the energy savings to NOx emissions reduction

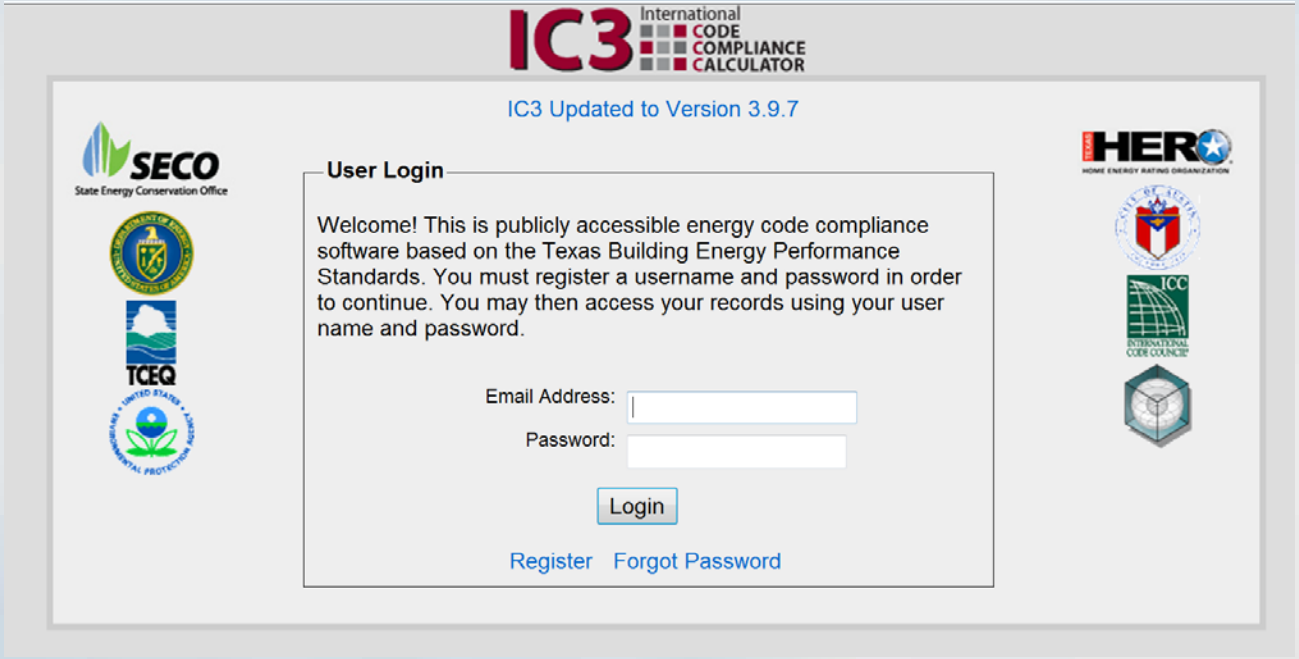


Single-family

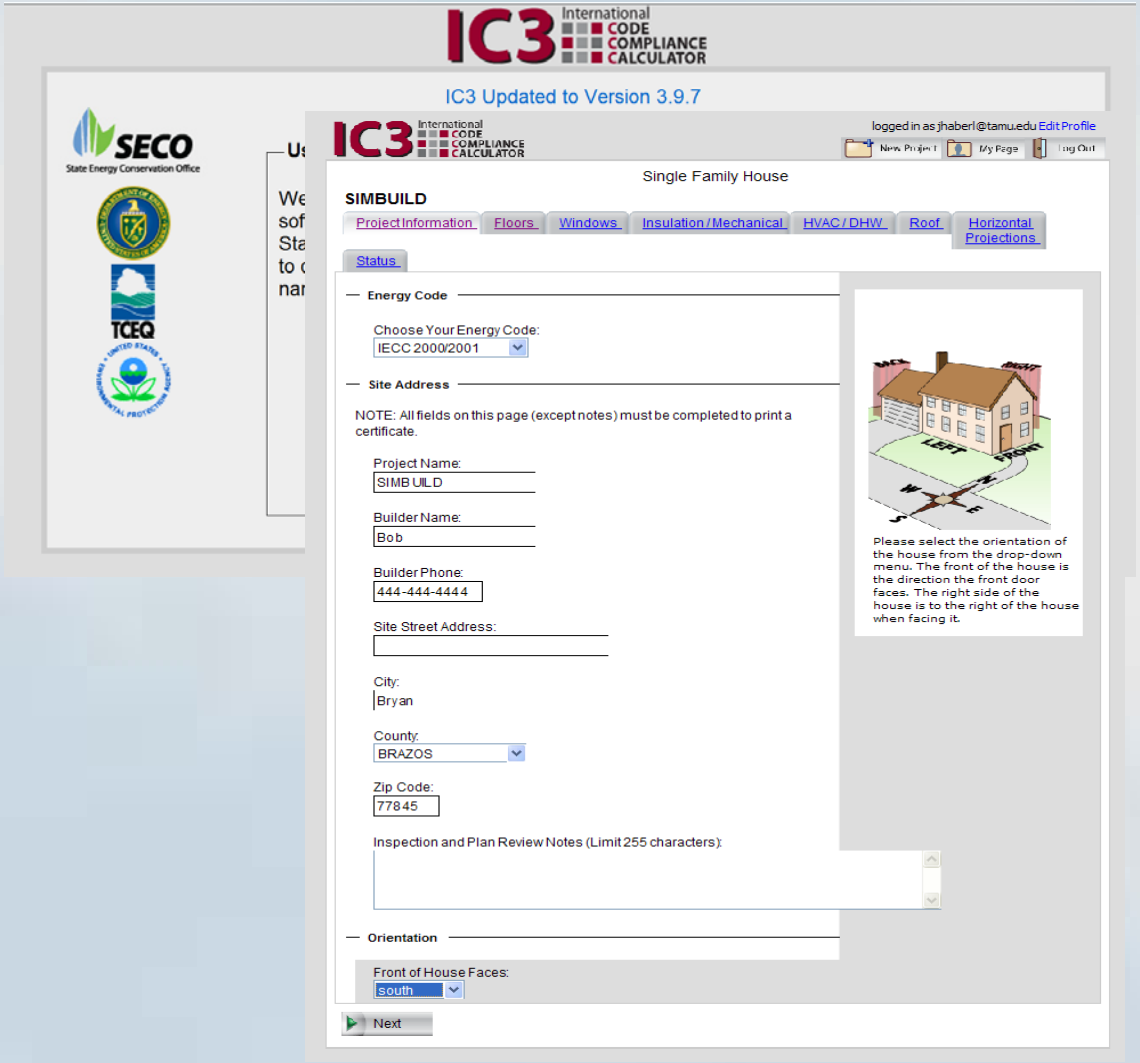


"ecalc.tamu.edu"

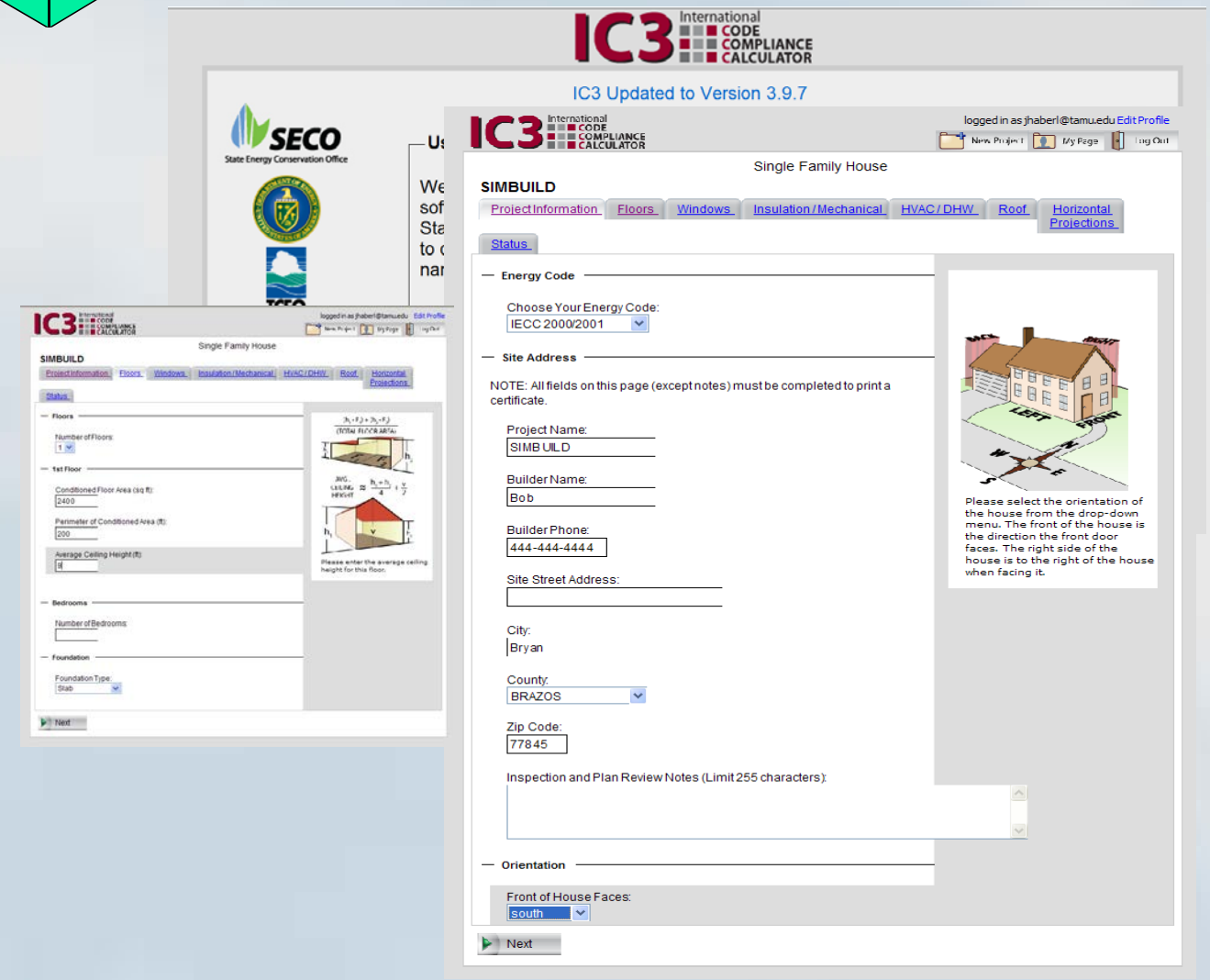
IECC CODE COMPLIANCE CALCULATOR



IECC CODE COMPLIANCE CALCULATOR

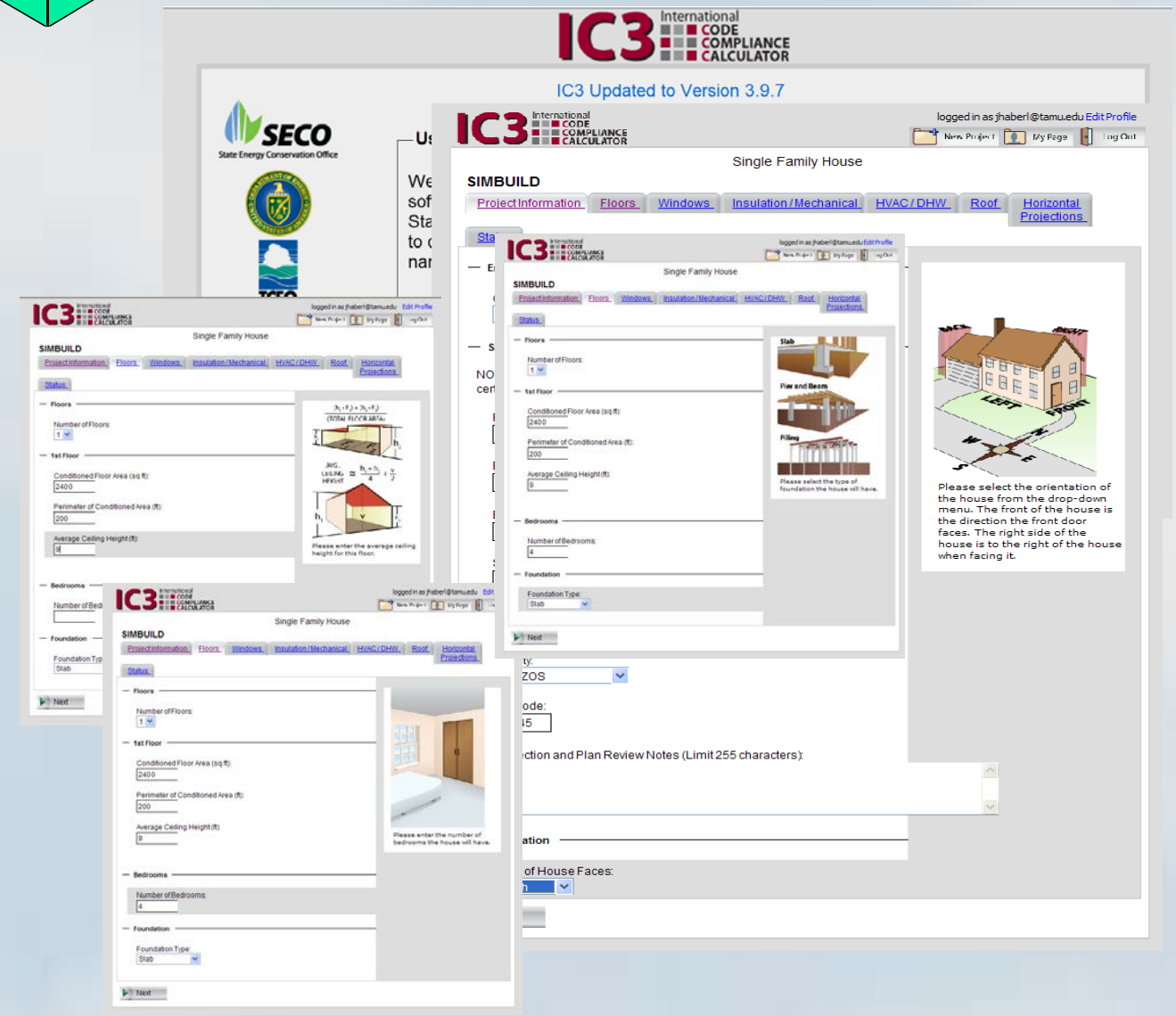


IECC CODE COMPLIANCE CALCULATOR



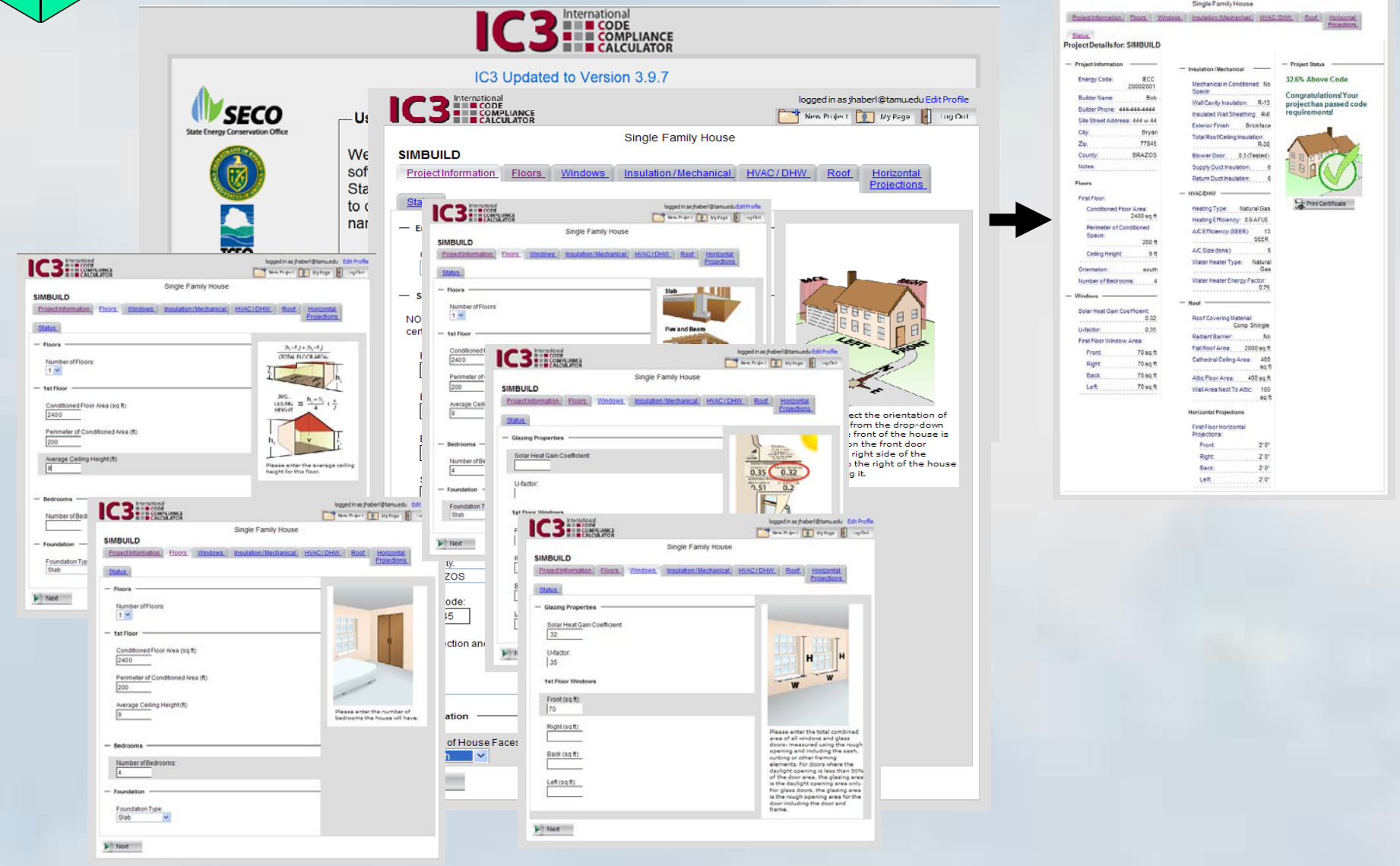
IECC CODE COMPLIANCE CALCULATOR

IECC CODE COMPLIANCE CALCULATOR

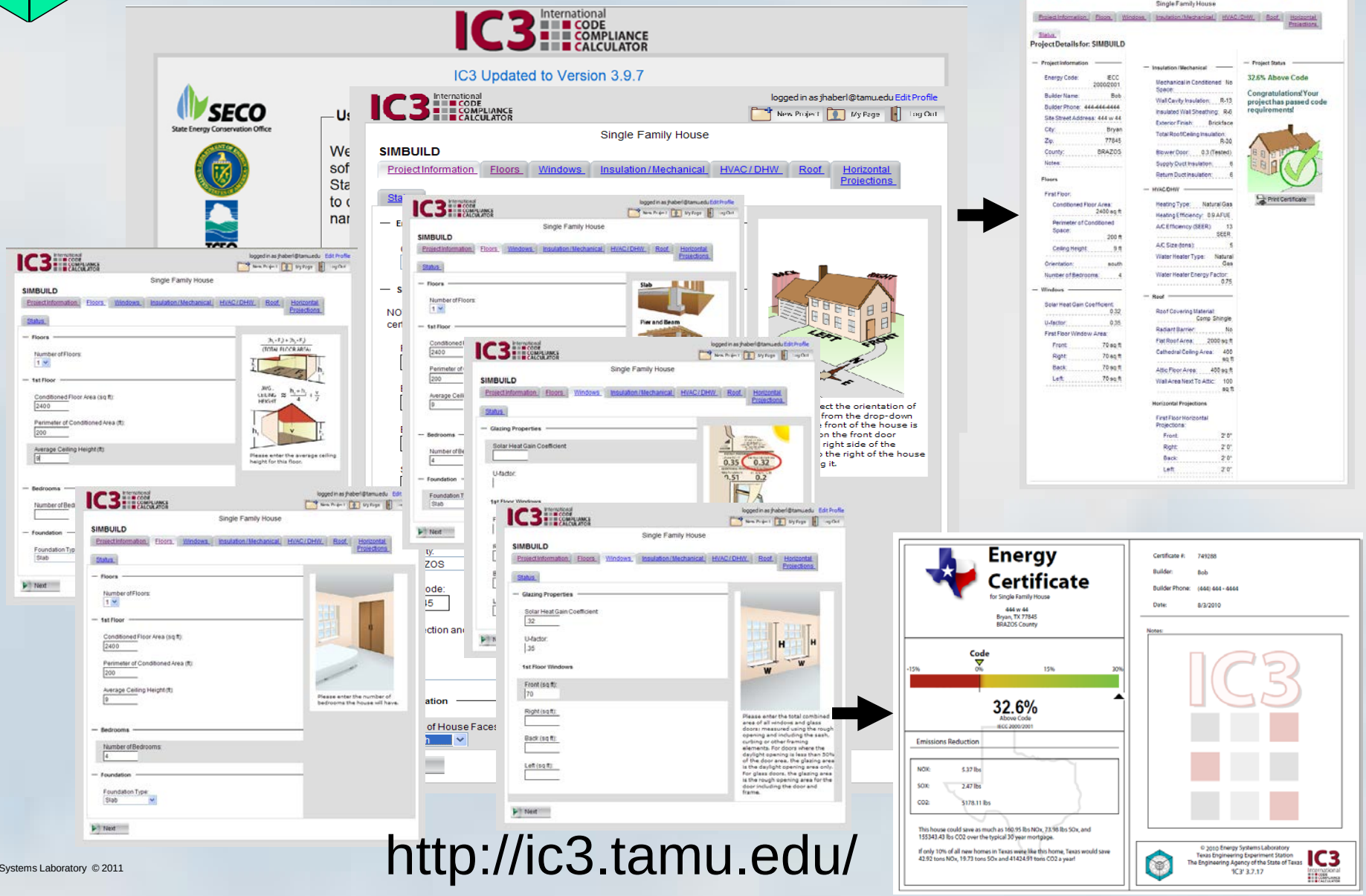


IECC CODE COMPLIANCE CALCULATOR

IECC CODE COMPLIANCE CALCULATOR



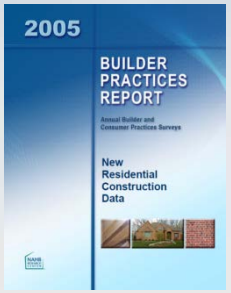
IECC CODE COMPLIANCE CALCULATOR

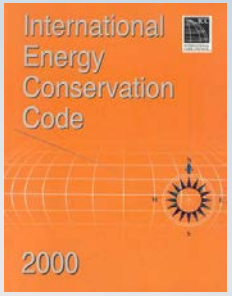


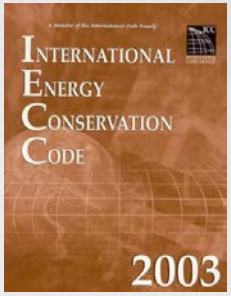
http://ic3.tamu.edu/

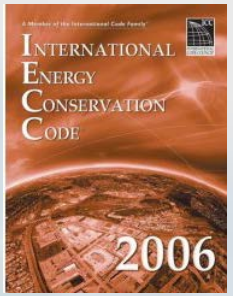
SAVINGS FROM CODE COMPLIANCE

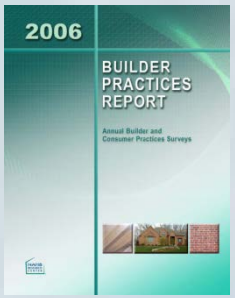
How much electricity has been saved from code compliance for all single family residential housing 2000 -2009?





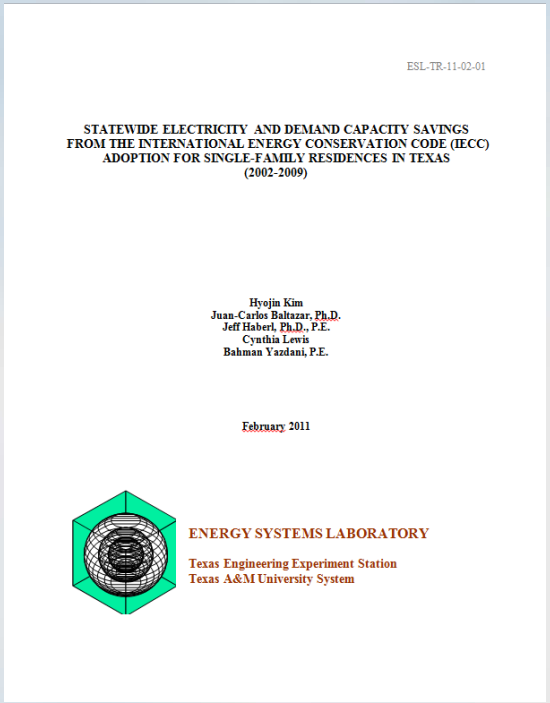






SAVINGS FROM CODE COMPLIANCE

How much electricity has been saved from code compliance for all single family residential housing 2000 -2009?

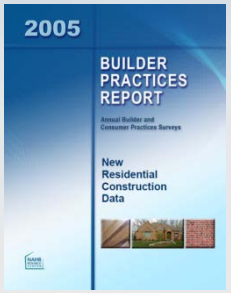

ESL-TR-11-02-01

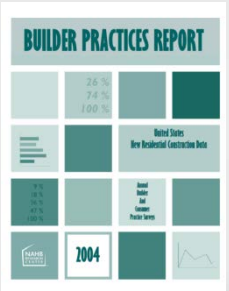
STATEWIDE ELECTRICITY AND DEMAND CAPACITY SAVINGS FROM THE INTERNATIONAL ENERGY CONSERVATION CODE (IECC) ADOPTION FOR SINGLE-FAMILY RESIDENCES IN TEXAS (2002-2009)

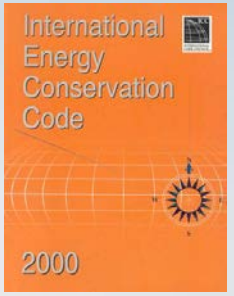
Hyojin Kim
Juan-Carlos Baltazar, Ph.D.
Jeff Haberl, Ph.D., P.E.
Cynthia Lewis
Bahman Yazdani, P.E.

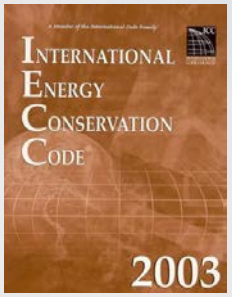
February 2011

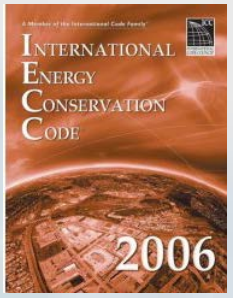
ENERGY SYSTEMS LABORATORY
Texas Engineering Experiment Station
Texas A&M University System

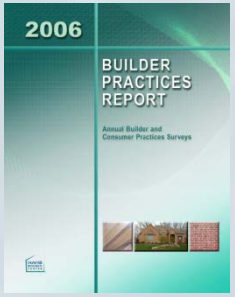


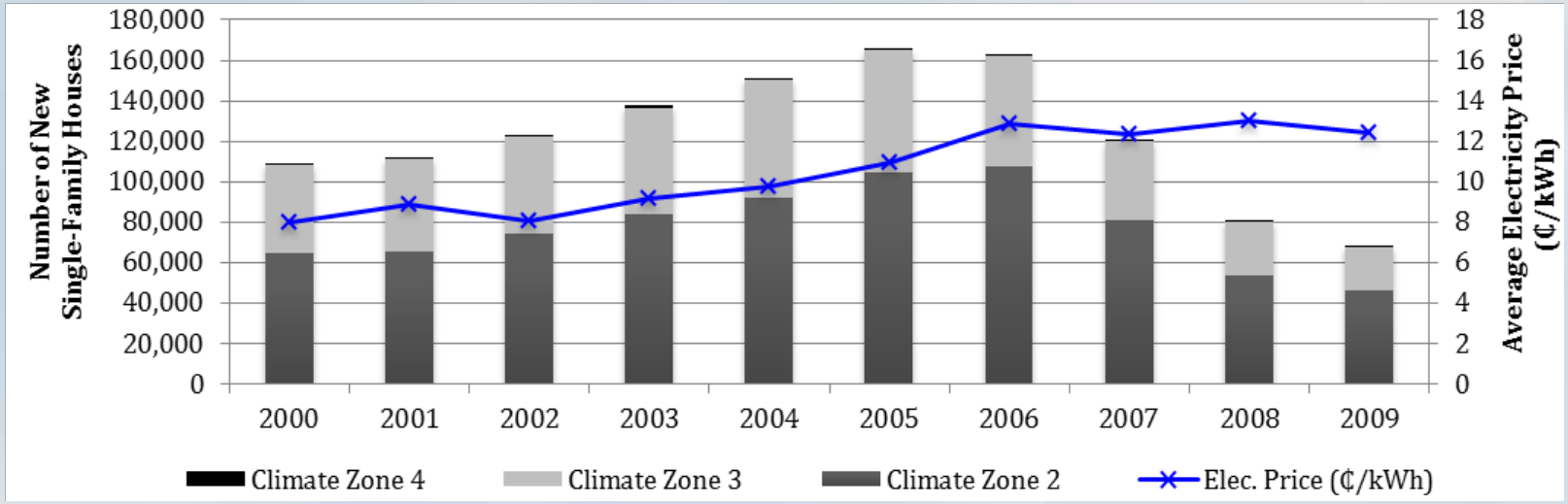




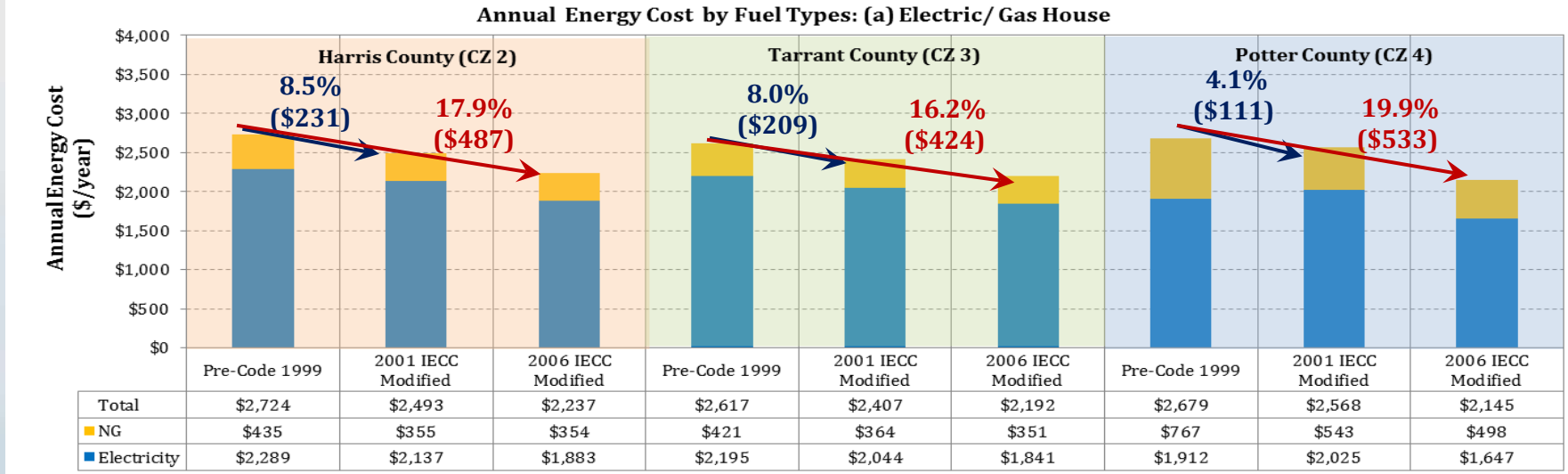




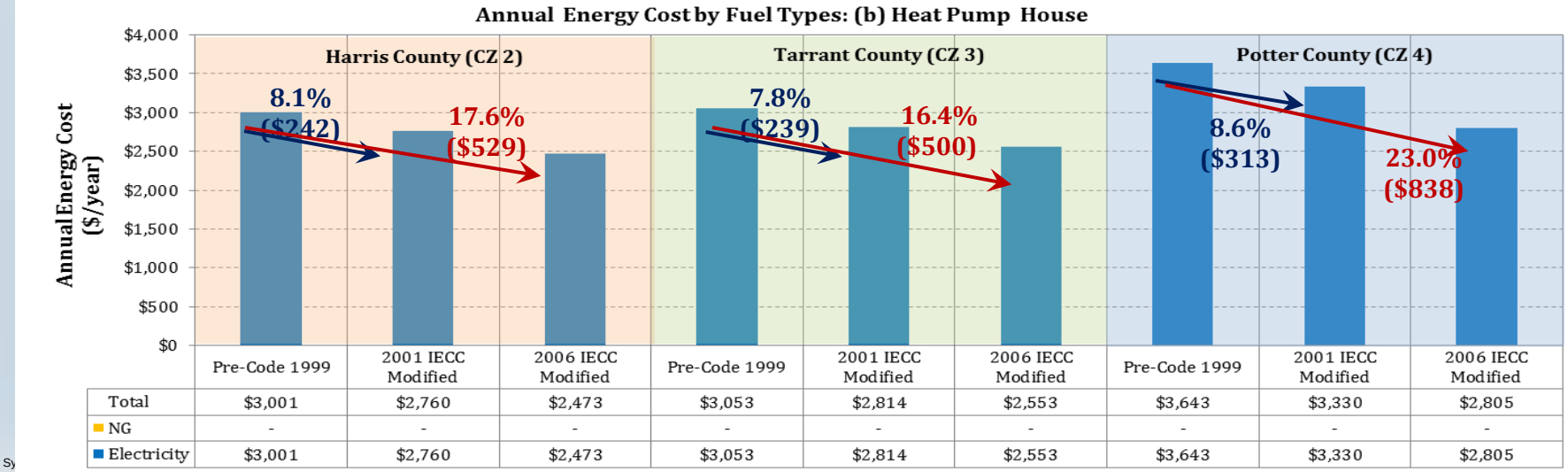




SAVINGS FROM CODE COMPLIANCE



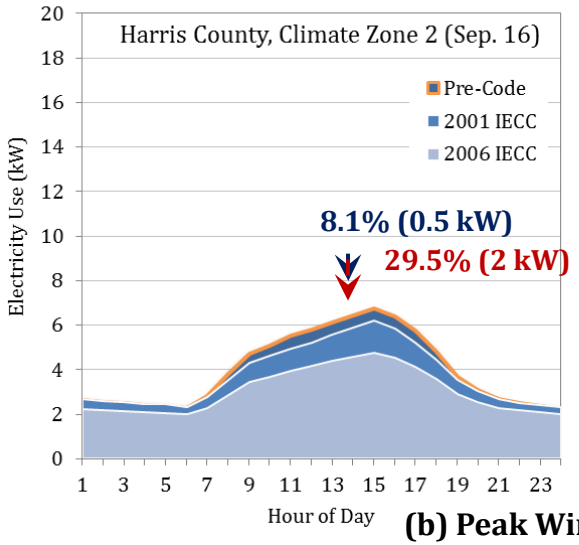
	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified
Total	$2,724	$2,493	$2,237	$2,617	$2,407	$2,192	$2,679	$2,568	$2,145
NG	$435	$355	$354	$421	$364	$351	$767	$543	$498
Electricity	$2,289	$2,137	$1,883	$2,195	$2,044	$1,841	$1,912	$2,025	$1,647

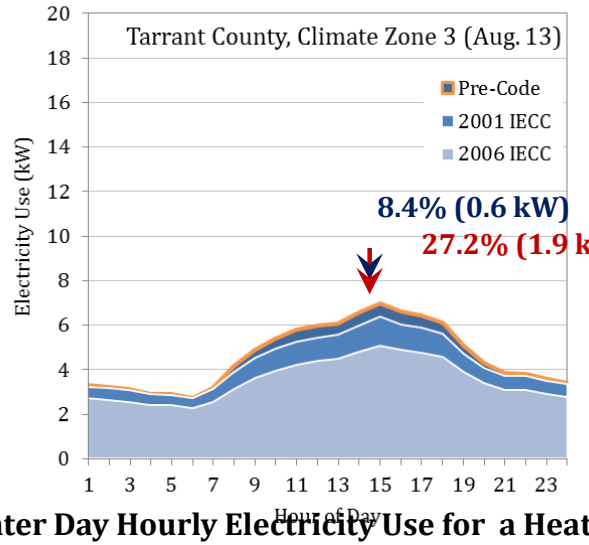


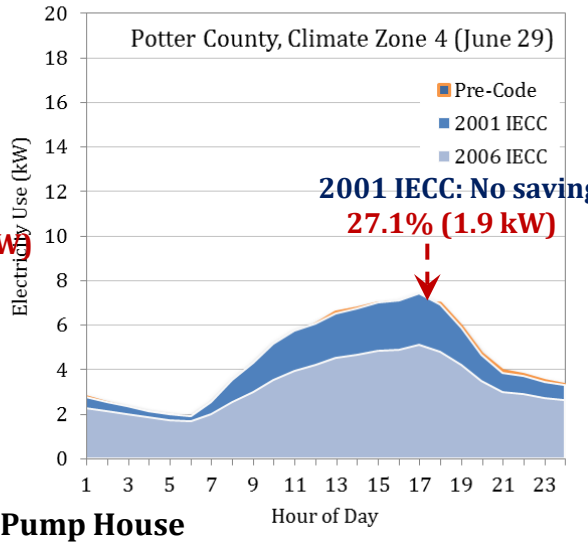
	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified	Pre-Code 1999	2001 IECC Modified	2006 IECC Modified
Total	$3,001	$2,760	$2,473	$3,053	$2,814	$2,553	$3,643	$3,330	$2,805
NG	-	-	-	-	-	-	-	-	-
Electricity	$3,001	$2,760	$2,473	$3,053	$2,814	$2,553	$3,643	$3,330	$2,805

SAVINGS FROM CODE COMPLIANCE

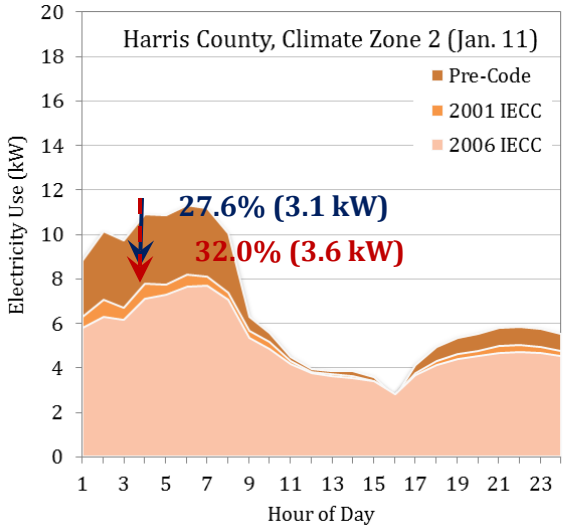
Peak Summer Day Hourly Electricity Use for both Electric/Gas and Heat Pump House

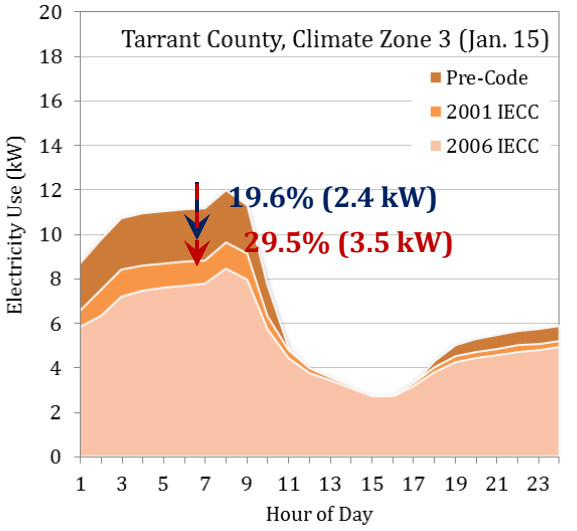


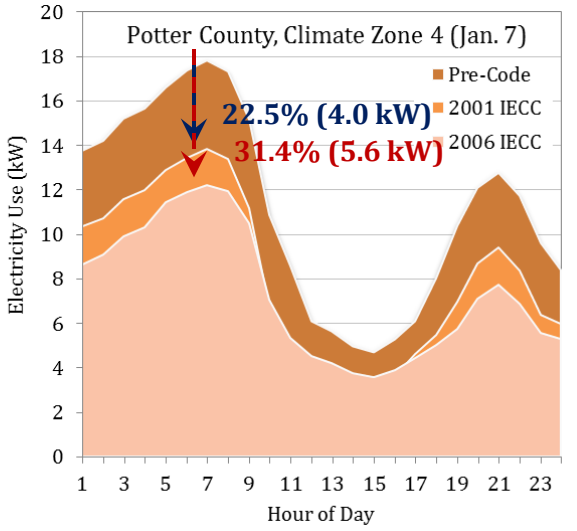




(b) Peak Winter Day Hourly Electricity Use for a Heat Pump House



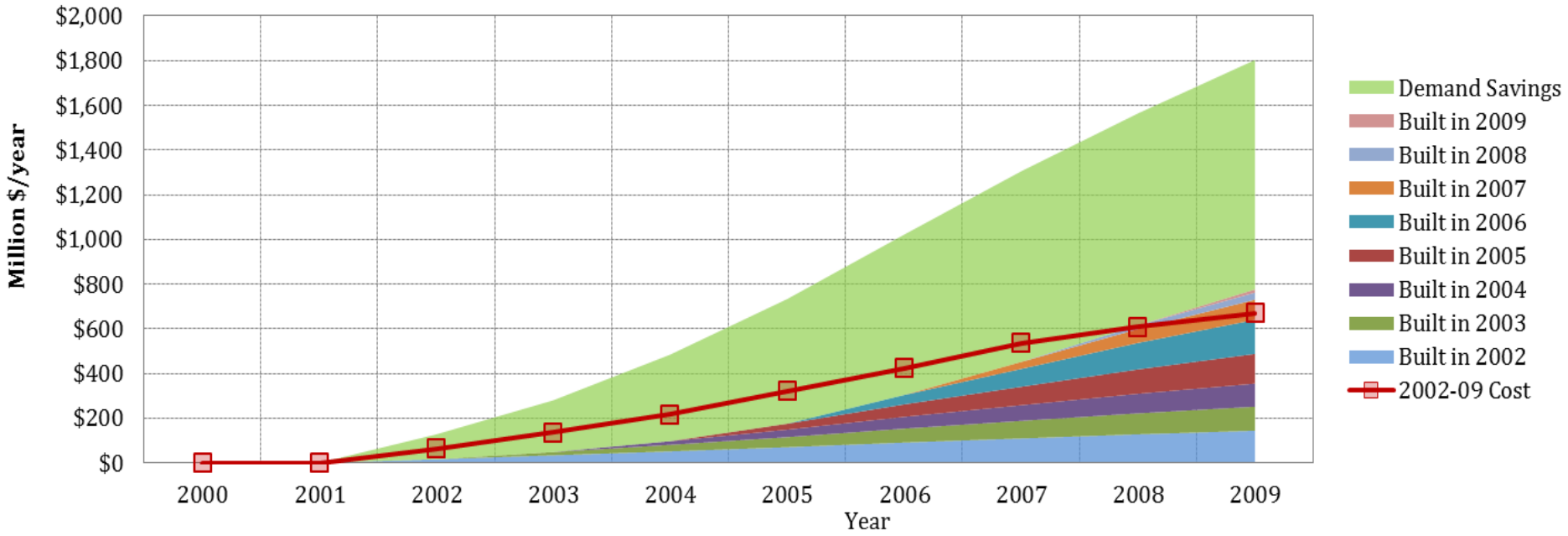




SAVINGS FROM CODE COMPLIANCE

Electricity Savings, Electric Demand Savings and Costs:

Total -	**$1,808 million**
Electricity -	$ 776 million
Demand -	$1,027 million
Costs -	$ 607 million

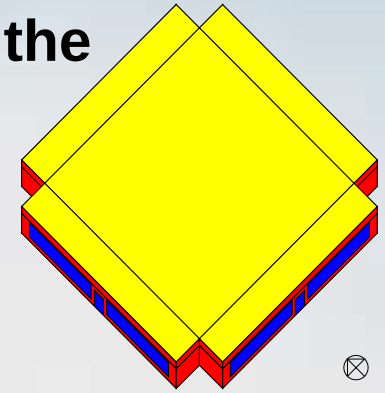


HOW MUCH SAVINGS? COMMERCIAL

To quantify the reduction of NOx emissions due to th implementation of ASHRAE Standard 90.1-1999:

HOW MUCH SAVINGS? COMMERCIAL

To quantify the reduction of NOx emissions due to the implementation of ASHRAE Standard 90.1-1999:

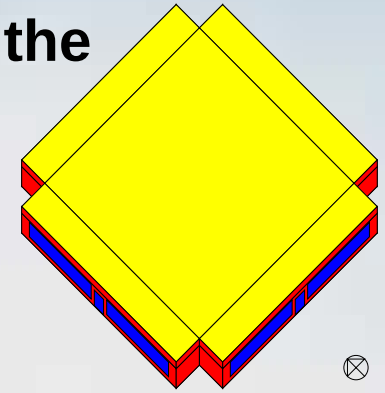


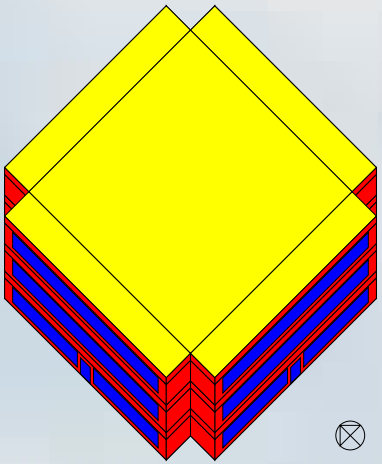
- Prototype simulation models were created using the DOE-2.1e simulation software
    - 1 story

HOW MUCH SAVINGS? COMMERCIAL

To quantify the reduction of NOx emissions due to the implementation of ASHRAE Standard 90.1-1999:

- Prototype simulation models were created using the DOE-2.1e simulation software
  - •1 story
  - •3 story

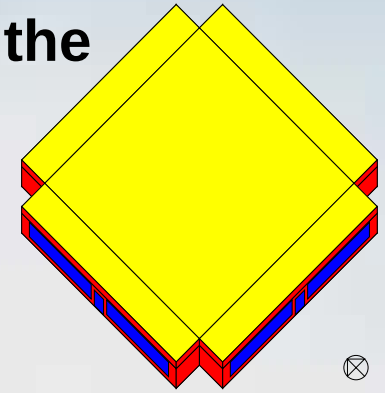


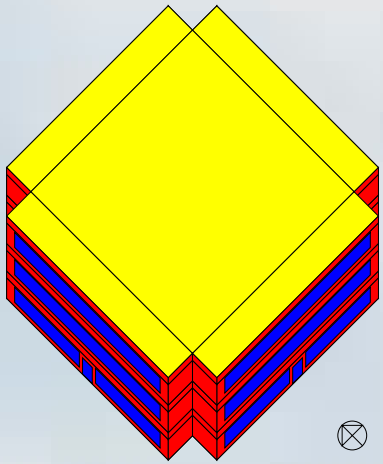


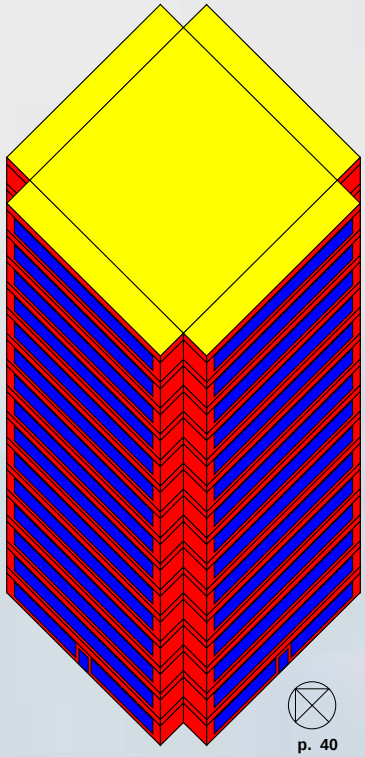
HOW MUCH SAVINGS? COMMERCIAL

To quantify the reduction of NOx emissions due to the implementation of ASHRAE Standard 90.1-1999:

- Prototype simulation models were created using the DOE-2.1e simulation software
  - •1 story
  - •3 story
  - •100 story



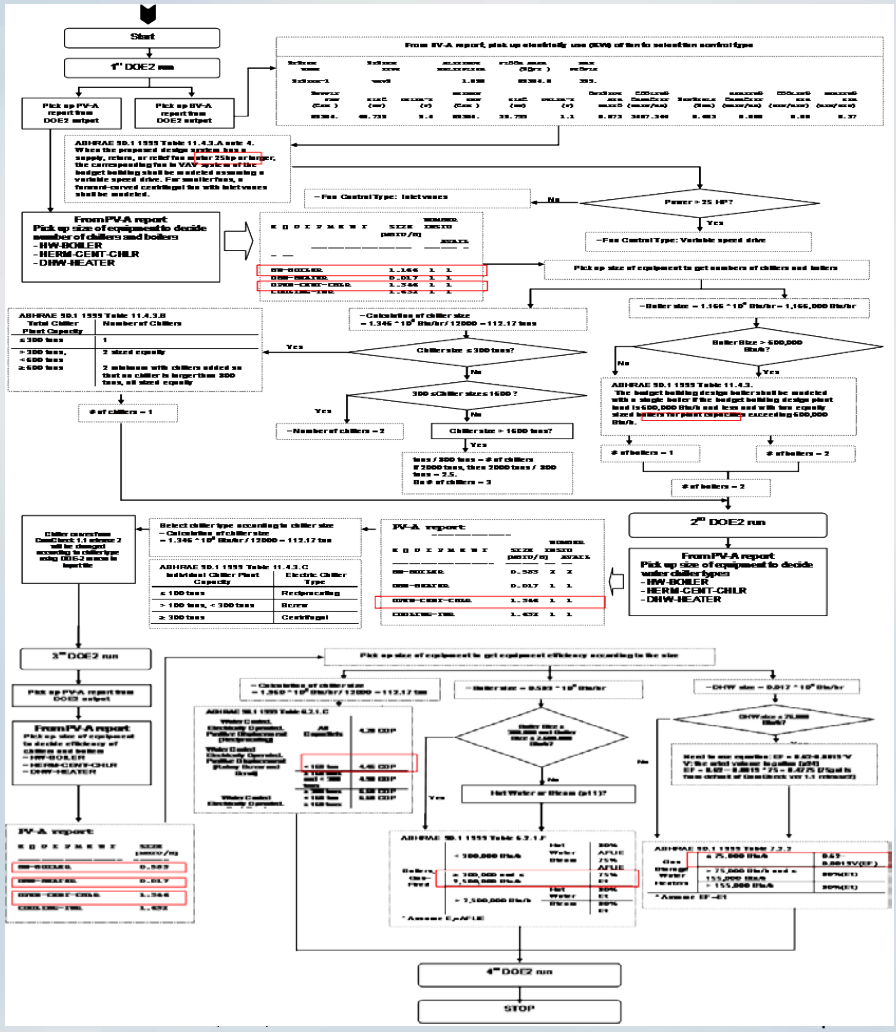




HOW MUCH SAVINGS? COMMERCIAL

To quantify the reduction of NOx emissions due to the implementation of ASHRAE Standard 90.1-1999:

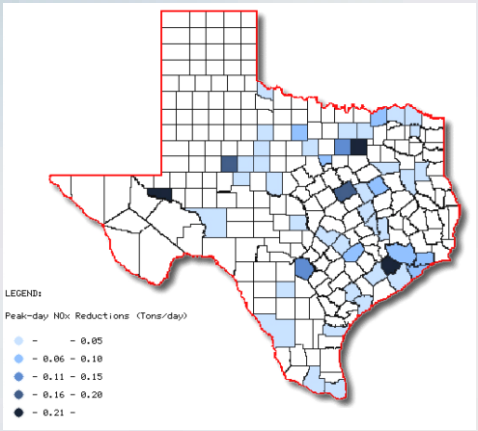
- Prototype simulation models were created using the DOE-2.1e simulation software
  - •1 story
  - •3 story
  - •100 story
- The models were then modified to accommodate the requirements of both ASHRAE Standard 90.1-1989 (baseline) and 1999 (new construction).

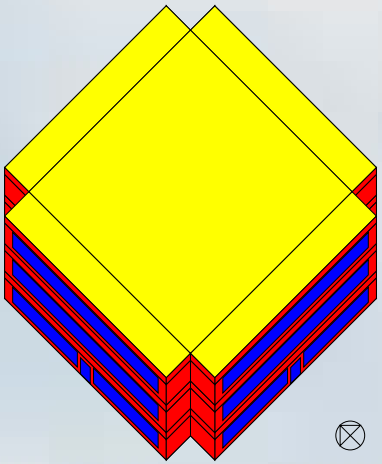


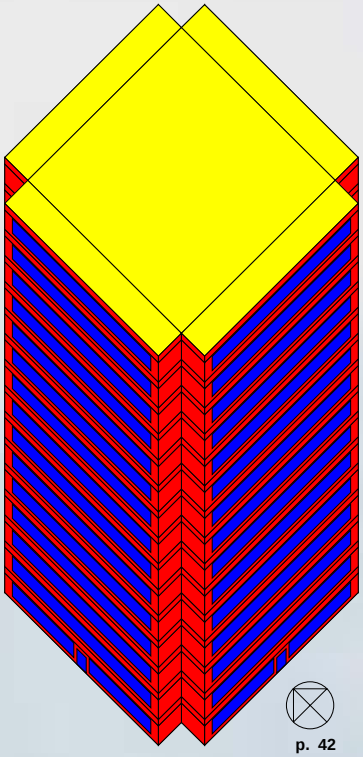
HOW MUCH SAVINGS? COMMERCIAL

To quantify the reduction of NOx emissions due to the implementation of ASHRAE Standard 90.1-1999:

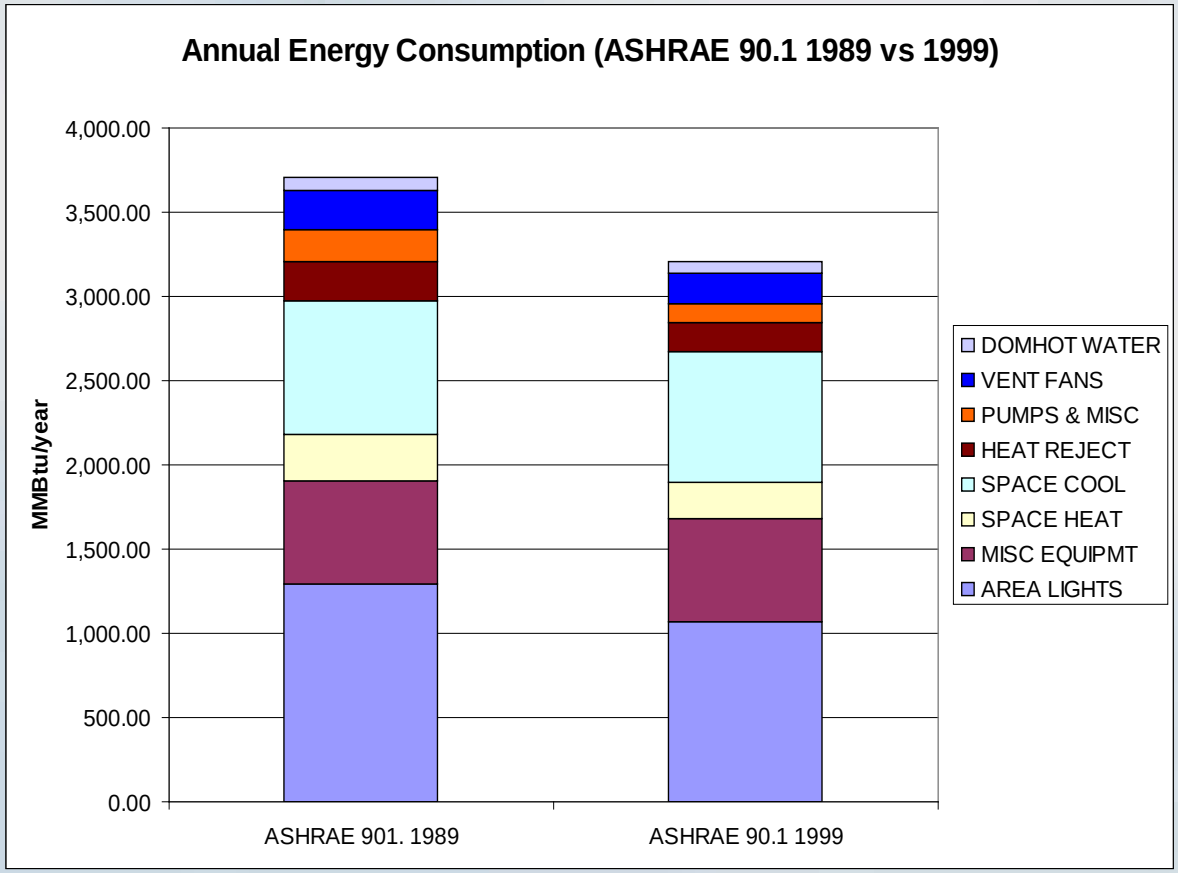
- Prototype simulation models were created using the DOE-2.1e simulation software
  - •1 story
  - •3 story
  - •100 story
- The models were then modified to accommodate the requirements of both ASHRAE Standard 90.1-1989 (baseline) and 1999 (new construction).
- The models were then linked to a web-based graphic user interface and US-EPA's eGRID to convert the energy savings to NOx emissions reduction





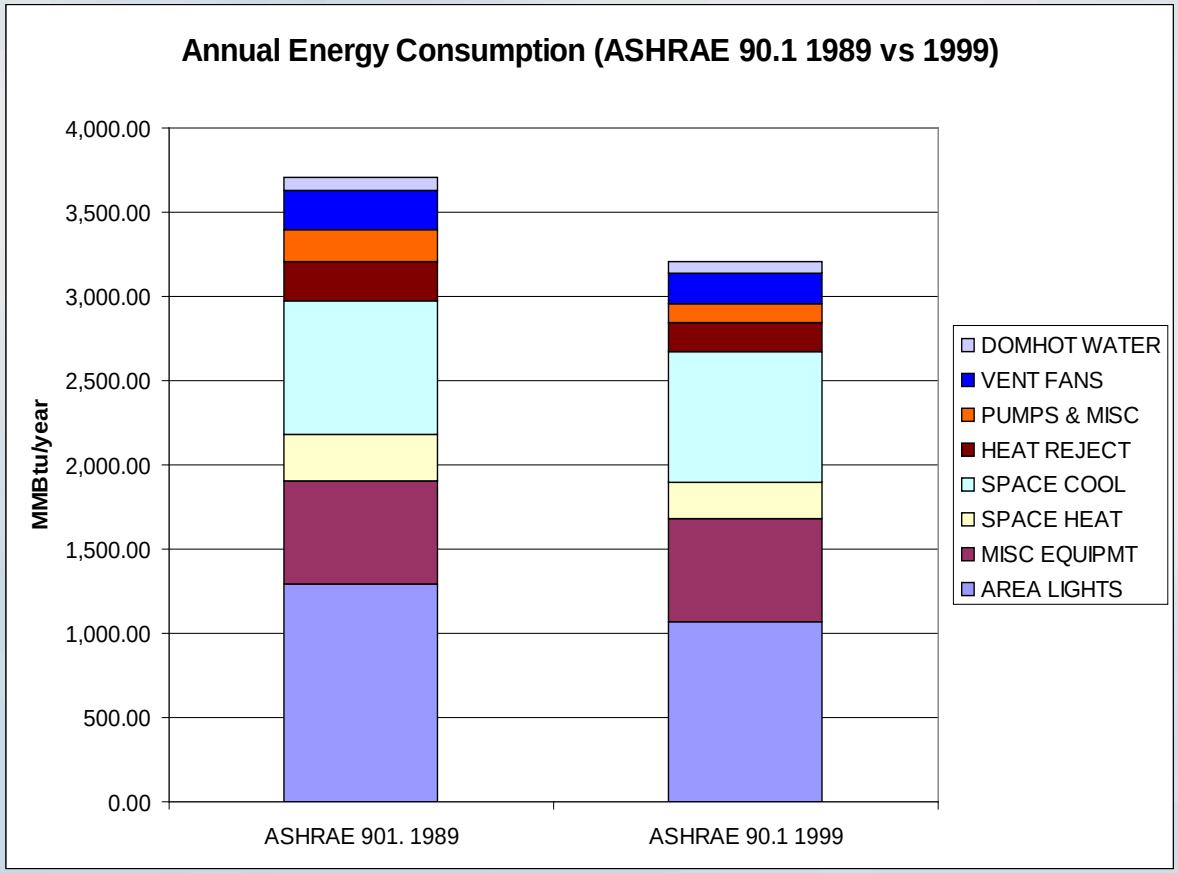


HOW MUCH SAVINGS? COMMERCIAL



HOW MUCH SAVINGS? COMMERCIAL

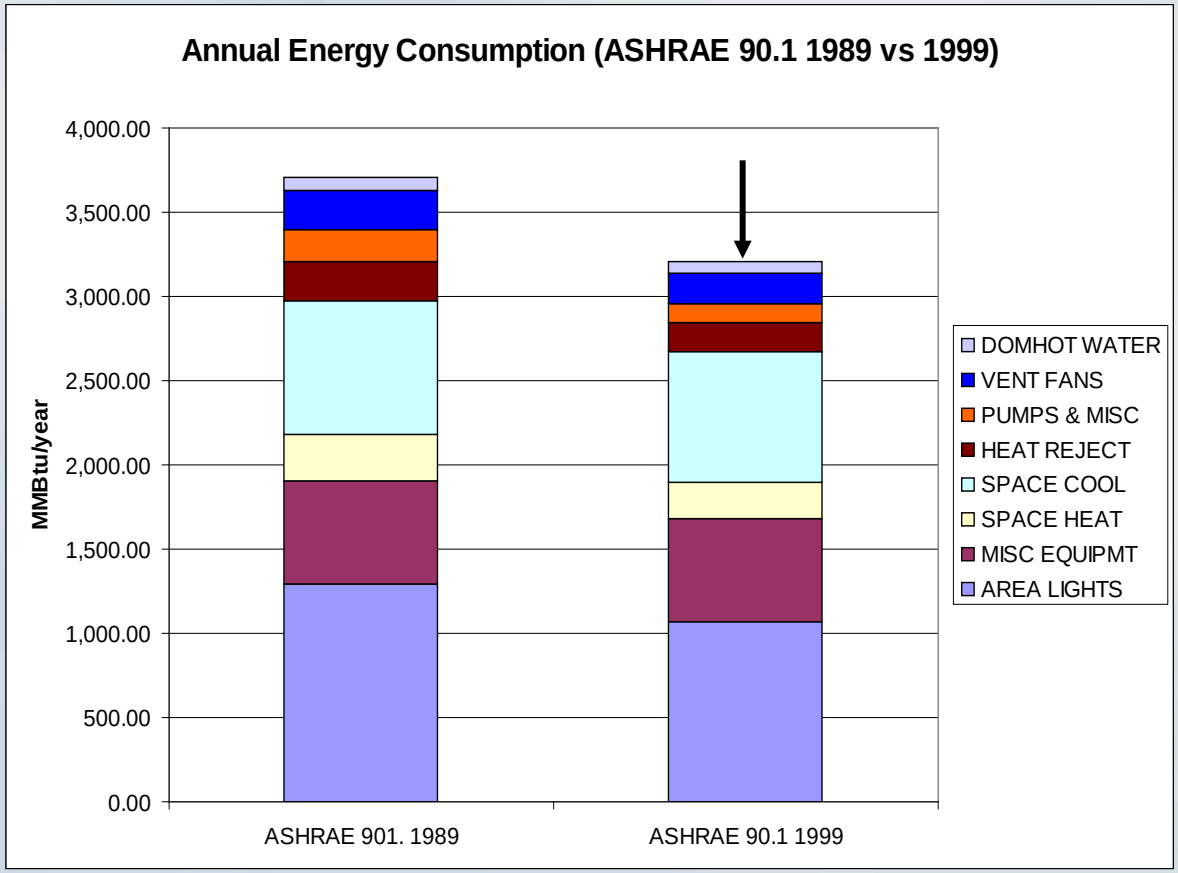
Comparison Between ASHRAE 90.1-1989 AND 90.1-1999:



HOW MUCH SAVINGS? COMMERCIAL

Comparison Between ASHRAE 90.1-1989 AND 90.1-1999:

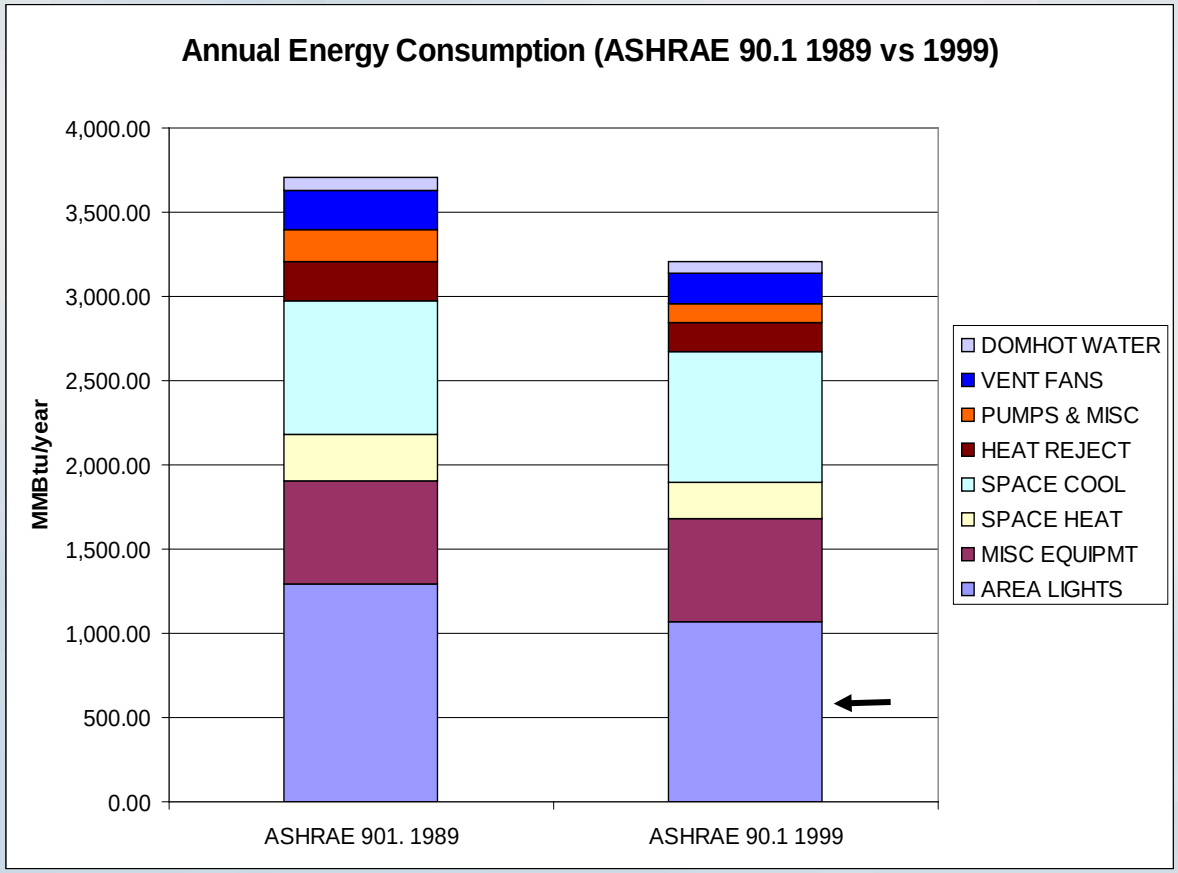
- For the same building, ASHRAE 90.1-1999 is *13.4% less consumptive* than ASHRAE 90.1-1989



HOW MUCH SAVINGS? COMMERCIAL

Comparison Between ASHRAE 90.1-1989 AND 90.1-1999:

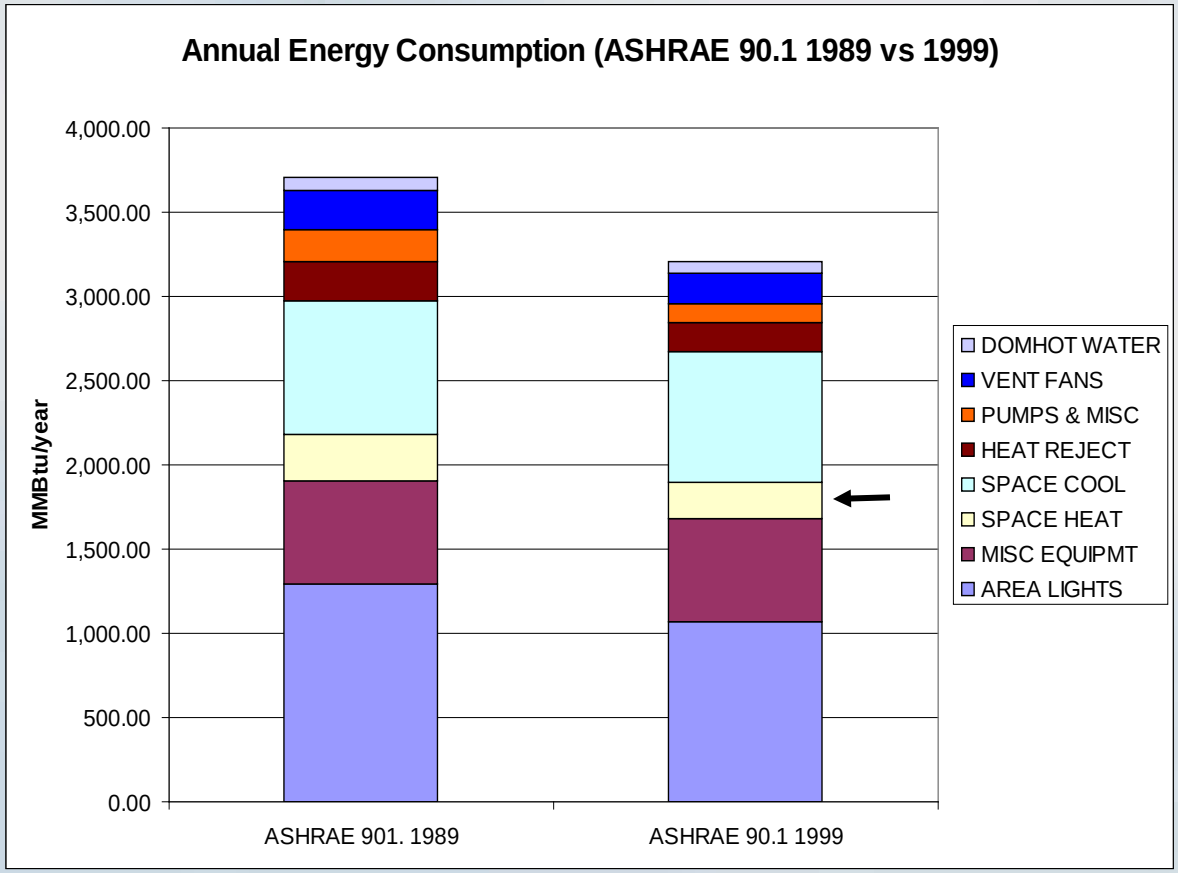
- For the same building, ASHRAE 90.1-1999 is *13.4% less consumptive* than ASHRAE 90.1-1989
- More stringent requirements for *the lighting power density (LPD) in 1999 make up for 45%* of the total decrease



HOW MUCH SAVINGS? COMMERCIAL

Comparison Between ASHRAE 90.1-1989 AND 90.1-1999:

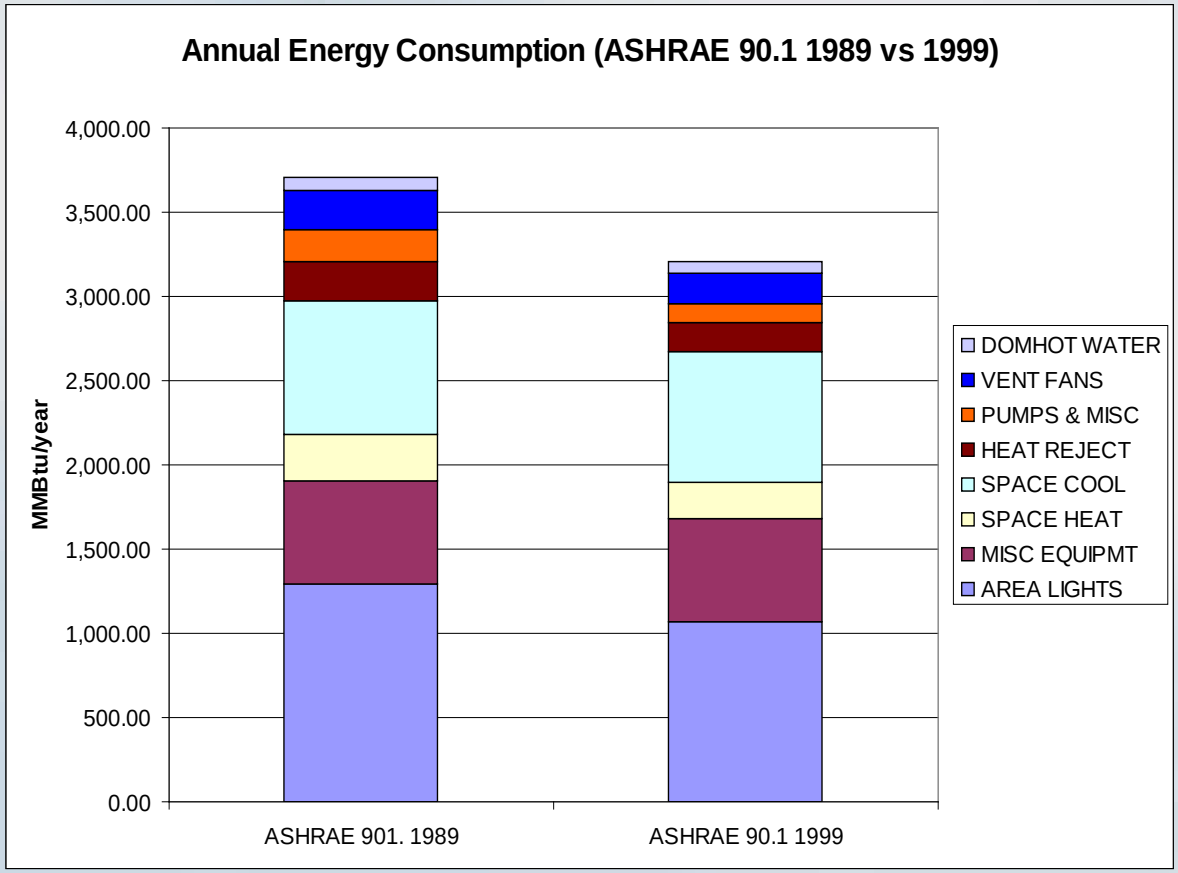
- For the same building, ASHRAE 90.1-1999 is *13.4% less consumptive* than ASHRAE 90.1-1989
- More stringent requirements for *the lighting power density (LPD) in 1999 make up for 45%* of the total decrease
- *Boiler staging* in 1999 also allows for *a 12% decrease* in the annual energy consumption as compared to 1989



HOW MUCH SAVINGS? COMMERCIAL

Comparison Between ASHRAE 90.1-1989 AND 90.1-1999:

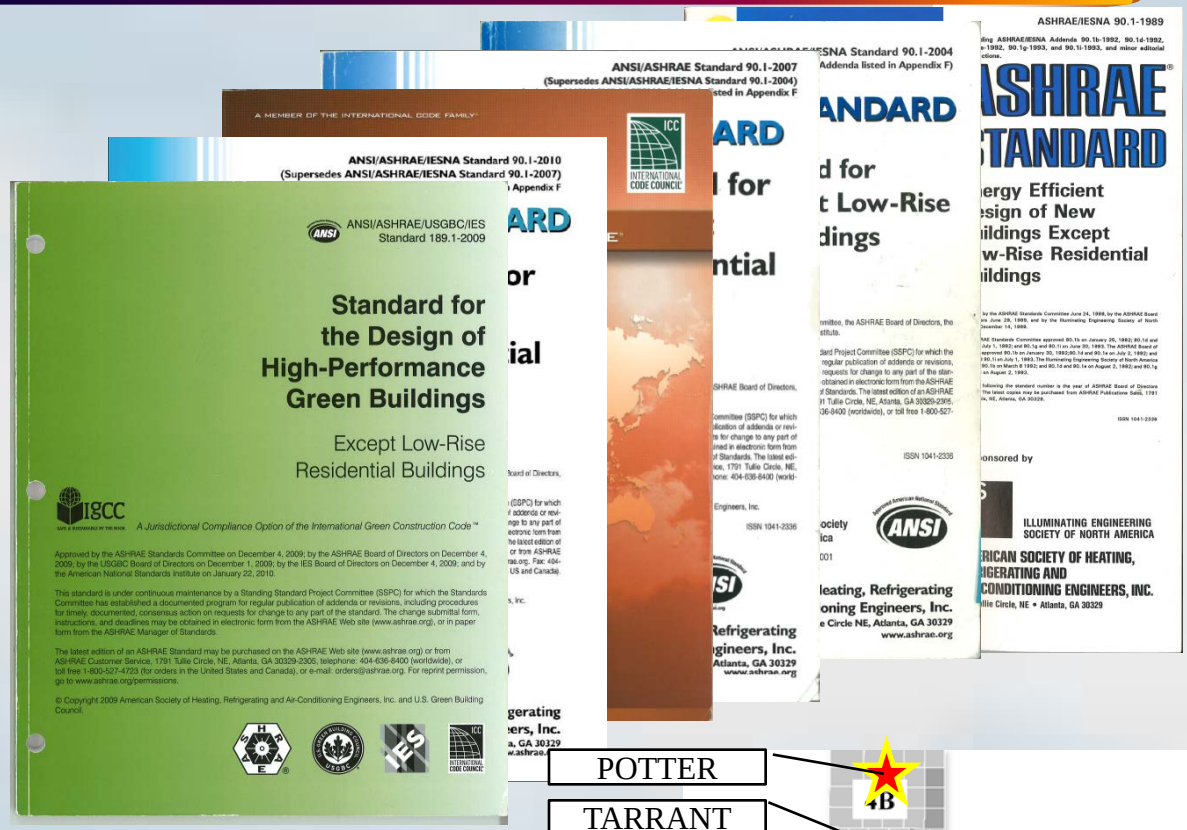
- For the same building, ASHRAE 90.1-1999 is *13.4% less consumptive* than ASHRAE 90.1-1989
- More stringent requirements for *the lighting power density (LPD) in 1999 make up for 45%* of the total decrease
- *Boiler staging* in 1999 also allows for *a 12% decrease* in the annual energy consumption as compared to 1989
- More *stringent envelope requirements* also help in decreasing fan and auxiliary energy consumption in 1999

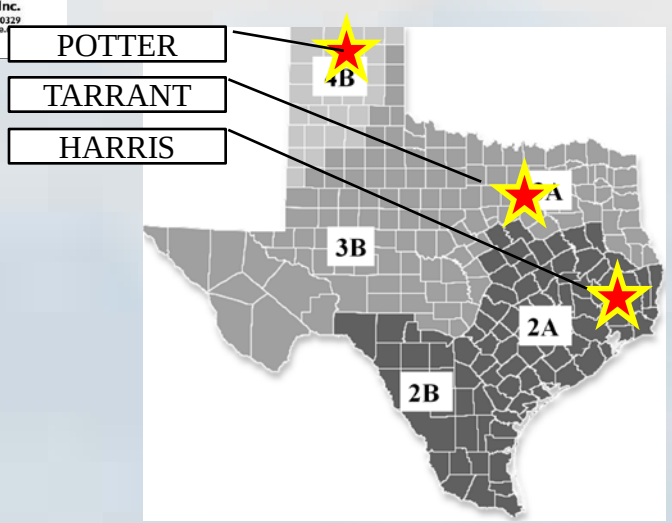


COMMERCIAL CODE COMPARISON

Codes compared:

ASHRAE 90.1-1989
ASHRAE 90.1-1999
ASHRAE 90.1-2004
ASHRAE 90.1-2007
ASHRAE 90.1-2010
ASHRAE 189.1-2009
IECC 2009





Three counties selected for analysis

COMMERCIAL CODE COMPARISON

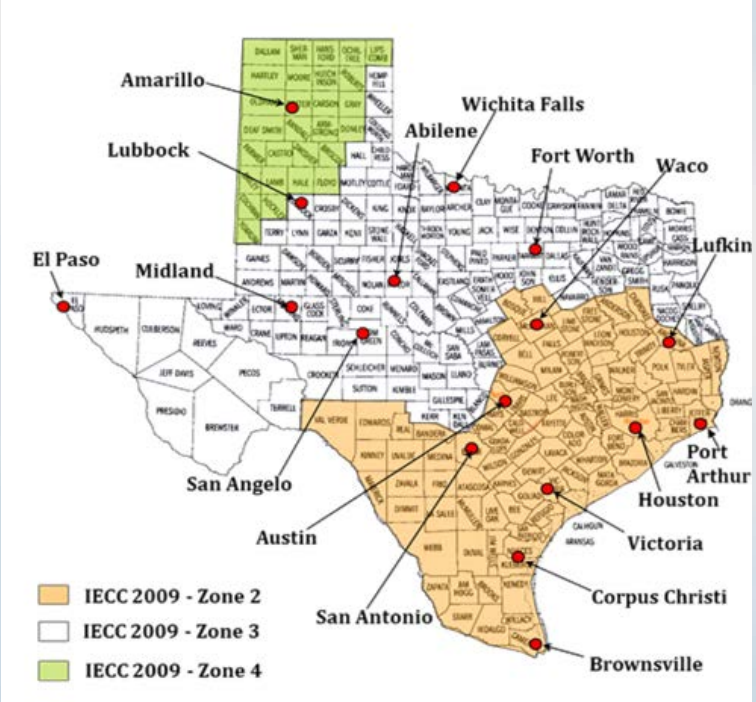
Results: Savings compared to 90.1-1989




	SITE ENERGY	SOURCE ENERGY
ASHRAE 90.1-1999	16.7%-18.6%	14.5%-15.0%
ASHRAE 90.1-2004	22.3%- 32.6%	21.6%-27.2%
ASHRAE 90.1-2007	28.1%-33.9%	23.5%-28.4%
IECC 2009	27.4%-35.3%	23.4%-25.8%
ASHRAE 90.1-2010	42.1%-47.7%	41.8%-45.7%
ASHRAE 189.1-2009	46.9%-54.9%	44.5%-51.8%

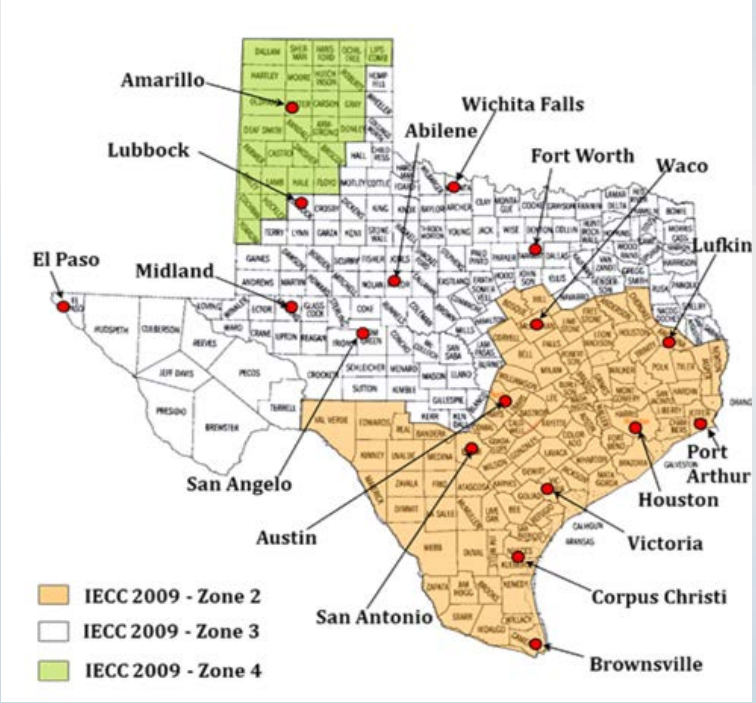

TECHNICAL ASSISTANCE

15% ABOVE 2009 CODE: STATEWIDE



TECHNICAL ASSISTANCE

15% ABOVE 2009 CODE: STATEWIDE

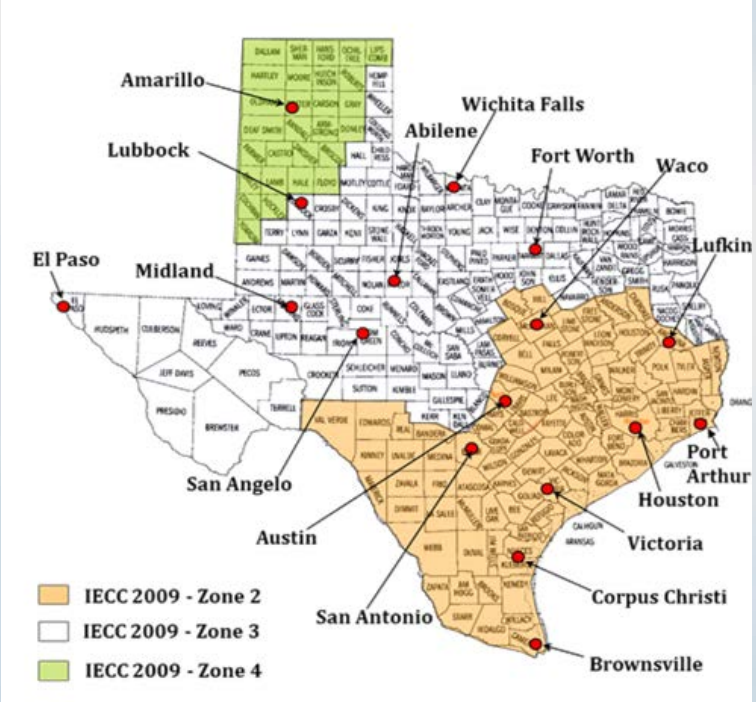


2011 - City of Arlington

- Residential
- Office
- Retail
- Restaurant

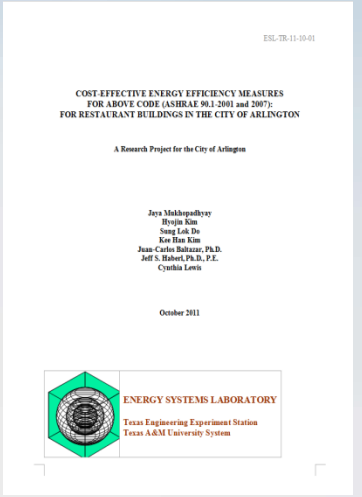
TECHNICAL ASSISTANCE

15% ABOVE 2009 CODE: STATEWIDE



2011 - City of Arlington

- Residential
- Office
- Retail
- Restaurant



ESL-TR-11-10-01

COST-EFFECTIVE ENERGY EFFICIENCY MEASURES
FOR ABOVE CODE (ASHRAE 90.1-2001 and 2007):
FOR RESTAURANT BUILDINGS IN THE CITY OF ARLINGTON

A Research Project for the City of Arlington

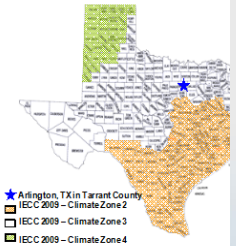
Jaya Mukhopadhyay
Hyojin Kim
Sung Lok Do
Kee Han Kim
Juan-Carlos Baltazar, Ph.D.
Jeff S. Haberl, Ph.D., P.E.
Cynthia Lewis

October 2011

ENERGY SYSTEMS LABORATORY
Texas Engineering Experiment Station
Texas A&M University System

Description of Individual Measures

	Individual Measures	Annual Energy Savings (%)[1] Site	Source	Annual Energy Savings ($/year)[2]	Estimated Cost ($) Marginal Cost[3]	New System Cost[4]	Simple Estimated Payback (yrs)
A	**Envelope and Fenestration Measures**						
1	Radiant Barrier in Attics (w ith Ducts in Attics)	1.8%	2.0%	$46		$300 - $880	6.6 - 19.2
2	Sealed (Unvented) Attic	7.6%	5.7%	$109	$2,000 - $3,500		18.3 - 32.0
3	Window Shading (None to 2 ft. Eaves on All Sides)	0.6%	2.0%	$56		$800 - $1,000	14.2 - 17.8
4	Window Shading and Redistribution (22.6% Equal Window s on All Sides w ith No Shading to S=40.7%, N=22.6%, EW= 13.6% w ith 2ft. Eaves on All Sides)	1.9%	3.0%	$73		$800 - $1,000	11.0 - 13.7
5	Decreased Window SHGC (from .3 to .2)	-0.6%	1.5%	$50	$200 - $400		4.0 - 8.0
6	Decreased Window U Value (from .5 to .3)	4.2%	4.2%	$93	$600 - $900		6.4 - 9.6
7	Decreased Window SHGC & U Value (from .3 to .2 SHGC & from .5 to .3 U-Value)	3.3%	5.6%	$142	$900 - $1,100		6.3 - 7.8
B	**HVAC System Measures**						
8	Relocate Mechanical Systems w ithin Conditioned Space	9.2%	8.2%	$172	$1,000 - $7,000		5.8 - 40.7
9	Improved Air Conditioner SEER (from 13 to 15 SEER)	3.8%	6.0%	$150	$900 - $2,500		6.0 - 16.6
10	Improved Furnace Efficiency (from 0.78 to 0.93 AFUE)	4.7%	2.3%	$33	$800 - $1,300		24.5 - 39.8
C	**Domestic Hot Water Measures**						
11	Tankless Gas Water Heater (w ithout a Standing Pilot Light)	3.3%	1.7%	$23	$900 - $1,400		39.1 - 60.8
12	Removal of Pilot Light from Domestic Hot Water System	1.6%	0.8%	$11	$100 - $500		9.2 - 46.0
13	Solar Domestic Hot Water System (32 sq. ft. collector, 65 gal tank)	9.9%	3.7%	$32		$2,200 - $3,000	67.7 - 92.4
14	Solar Domestic Hot Water System (64 sq. ft. collector, 80 gal tank)	12.6%	5.0%	$51		$3,200 - $4,000	63.2 - 79.0
D	**Lighting Measures**						
15	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	2.0%	4.2%	$112	$25 - $110		0.2 - 1.0
16	100% Energy Star Permanent CFL or Fluorescent Indoor Lamps	4.2%	8.7%	$228	$50 - $215		0.2 - 0.9
E	**Renewable Power Measures**						
17	4 kW Photovoltaic Array	19.9%	28.4%	$692		$20,000 - $30,000	28.9 - 43.3



Description of Combined Measures

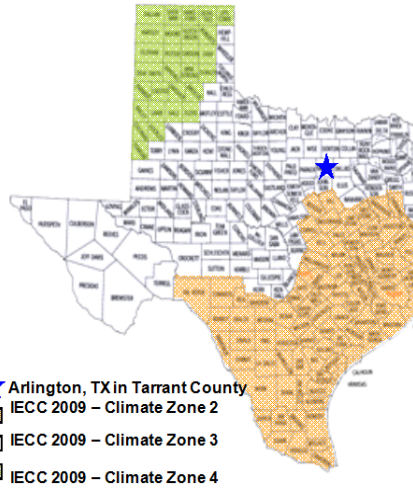
	Combination of Measures[5]	Combined Energy Savings (%)[1] Site	Source	Combined Energy Savings ($/year)[2]	Combined Estimated Cost ($) Marginal Cost[3]	New System Cost[4]	Simple Estimated Payback (yrs)	NOx Emissions Savings Annual (lbs/yr)	SO_2 Emissions Savings Annual (lbs/yr)	CO_2 Emissions Savings Annual (tons[6]/yr)
	Combination 1									
16	100% Energy Star Permanent CFL or Fluorescent Indoor Lamps	8.6%	15.8%	$403	$50 - $215		3.1 - 5.4	5.8	3.9	2.4
7	Decreased Window SHGC & U Value (from .3 to .2 SHGC & from .5 to .3 U-Value)				$900 - $1,100					
1	Radiant Barrier in Attics (w ith Ducts in Attics)					$300 - $880				
	Combination 2									
16	100% Energy Star Permanent CFL or Fluorescent Indoor Lamps	13.1%	17.0%	$405	$50 - $215		4.3 - 9.9	5.8	3.6	2.5
9	Improved Air Conditioner SEER (from 13 to 15 SEER)				$900 - $2,500					
10	Improved Furnace Efficiency (from 0.78 to 0.93 AFUE)				$800 - $1,300					
	Combination 3									
8	Relocate Mechanical Systems w ithin Conditioned Space	16.0%	15.0%	$317	$1,000 - $7,000		8.5 - 29.7	4.6	2.3	2.1
10	Improved Furnace Efficiency (from 0.78 to 0.93 AFUE)				$800 - $1,300					
7	Decreased Window SHGC & U Value (from .3 to .2 SHGC & from .5 to .3 U-Value)				$900 - $1,100					

Note:
1. Total energy savings from heating, cooling, lighting, equipment and DHW for emissions reductions determination.
2. Savings depend on fuel mix used.
   * Energy Cost: Electricity = $0.11/kWh
     Natural gas = $0.64/therm
3. Marginal cost = new system cost - original system cost
4. New system cost = new system cost only
5. See individual measures above for specific savings
6. Conversion factor: 1 ton = 2,000 lbs

[2009 IECC Code-Compliant House Description]
* Building type: Residential
* Gross area: 2,325 sq-ft
* Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
* Number of floors: 1
* Floor-to-floor height: 8ft
* Window -to-floor ratio: 15% (Window -to-w all ratio: 22.6%)
* Lighting: 50% Energy Star permanent CFL or fluorescent lamps
* HVAC system: SEER 13 AC and 0.78 AFUE furnace
* DHW: 0.59 EF NG heater
* Duct Location: Unconditioned, vented attic
* Duct Leakage to Outdoor: 8 cfm/100 sq-ft CFA

Description of Individual Measures

	Individual Measures	Annual Energy Savings (%)[1]		Annual Energy Savings ($/year)[2]	Estimated Cost ($)		Simple Estimated Payback (yrs)
		Site	Source		Marginal Cost[3]	New System Cost[4]	
A	**Envelope and Fenestration Measures**						
1	Radiant Barrier in Attics (with Ducts in Attics)	1.8%	**2.0%**	$46		$300 - $880	6.6 - 19.2
2	Sealed (Unvented) Attic	7.6%	**5.7%**	$109	$2,000 - $3,500		18.3 - 32.0
3	Window Shading (None to 2 ft. Eaves on All Sides)	0.6%	**2.0%**	$56		$800 - $1,000	14.2 - 17.8
4	Window Shading and Redistribution (22.6% Equal Windows on All Sides with No Shading to S=40.7%, N=22.6%, E/W = 13.6% with 2ft. Eaves on All Sides)	1.9%	**3.0%**	$73		$800 - $1,000	11.0 - 13.7
5	Decreased Window SHGC (from .3 to .2)	-0.6%	**1.5%**	$50	$200 - $400		4.0 - 8.0
6	Decreased Window U Value (from .5 to .3)	4.2%	**4.2%**	$93	$600 - $900		6.4 - 9.6
7	Decreased Window SHGC & U Value (from .3 to .2 SHGC & from .5 to .3 U-Value)	3.3%	**5.6%**	$142	$900 - $1,100		6.3 - 7.8
B	**HVAC System Measures**						
8	Relocate Mechanical Systems within Conditioned Space	9.2%	**8.2%**	$172	$1,000 - $7,000		5.8 - 40.7
9	Improved Air Conditioner SEER (from 13 to 15 SEER)	3.8%	**6.0%**	$150	$900 - $2,500		6.0 - 16.6
10	Improved Furnace Efficiency (from 0.78 to 0.93 AFUE)	4.7%	**2.3%**	$33	$800 - $1,300		24.5 - 39.8
C	**Domestic Hot Water Measures**						
11	Tankless Gas Water Heater (without a Standing Pilot Light)	3.3%	**1.7%**	$23	$900 - $1,400		39.1 - 60.8
12	Removal of Pilot Light from Domestic Hot Water System	1.6%	**0.8%**	$11	$100 - $500		9.2 - 46.0
13	Solar Domestic Hot Water System (32 sq. ft. collector, 65 gal tank)	9.9%	**3.7%**	$32		$2,200 - $3,000	67.7 - 92.4
14	Solar Domestic Hot Water System (64 sq. ft. collector, 80 gal tank)	12.6%	**5.0%**	$51		$3,200 - $4,000	63.2 - 79.0
D	**Lighting Measures**						
15	75% Energy Star Permanent CFL or Fluorescent Indoor Lamps	2.0%	**4.3%**	$112	$25 - $110		0.2 - 1.0
16	100% Energy Star Permanent CFL or Fluorescent Indoor Lamps	4.2%	**8.7%**	$228	$50 - $215		0.2 - 0.9
E	**Renewable Power Measures**						
17	4 kW Photovoltaic Array	19.9%	**28.4%**	$692		$20,000 - $30,000	28.9 - 43.3



Description of Combined Measures

	Combination of Measures[5]	Combined Energy Savings (%)[1]		Combined Energy Savings ($/year)[2]	Combined Estimated Cost ($)		Simple Estimated Payback (yrs)	NOx Emissions Savings	SO_2 Emissions Savings	CO_2 Emissions Savings
		Site	Source		Marginal Cost[3]	New System Cost[4]		Annual (lbs/yr)	Annual (lbs/yr)	Annual (tons[6]/yr)
	Combination 1									
16	100% Energy Star Permanent CFL or Fluorescent Indoor Lamps	8.6%	**15.8%**	$403	$50 - $215		3.1 - 5.4	5.8	3.9	2.4
7	Decreased Window SHGC & U Value (from .3 to .2 SHGC & from .5 to .3 U-Value)				$900 - $1,100					
1	Radiant Barrier in Attics (with Ducts in Attics)					$300 - $880				
	Combination 2									
16	100% Energy Star Permanent CFL or Fluorescent Indoor Lamps	13.1%	**17.0%**	$405	$50 - $215		4.3 - 9.9	5.8	3.6	2.5
9	Improved Air Conditioner SEER (from 13 to 15 SEER)				$900 - $2,500					
10	Improved Furnace Efficiency (from 0.78 to 0.93 AFUE)				$800 - $1,300					
	Combination 3									
8	Relocate Mechanical Systems within Conditioned Space	16.0%	**15.0%**	$317	$1,000 - $7,000		8.5 - 29.7	4.6	2.3	2.1
10	Improved Furnace Efficiency (from 0.78 to 0.93 AFUE)				$800 - $1,300					
7	Decreased Window SHGC & U Value (from .3 to .2 SHGC & from .5 to .3 U-Value)				$900 - $1,100					

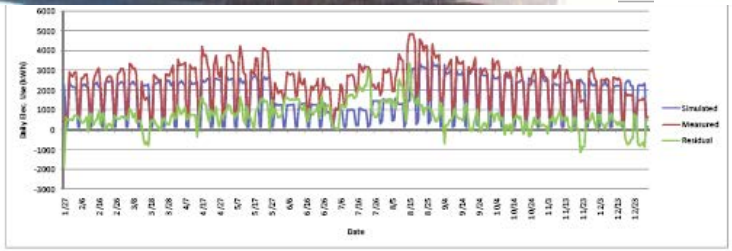
Note:
1. Total energy savings from heating, cooling, lighting, equipment and DHW for emissions reductions determination.
2. Savings depend on fuel mix used.
   * Energy Cost: Electricity = $0.11/kWh
     Natural gas = $0.64/therm
3. Marginal cost = new system cost - original system cost
4. New system cost = new system cost only
5. See individual measures above for specific savings
6. Conversion factor: 1 ton = 2,000 lbs

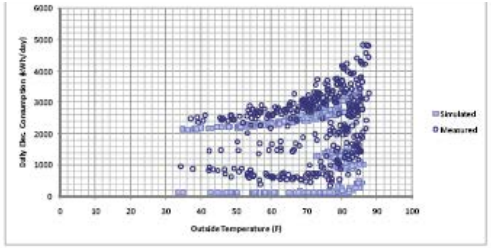
[2009 IECC Code-Compliant House Description]
* Building type: Residential
* Gross area: 2,325 sq-ft
* Building dimension: 48.2ft x 48.2ft x 8ft (WxLxH)
* Number of floors: 1
* Floor-to-floor height: 8ft
* Window-to-floor ratio: 15% (Window-to-wall ratio: 22.6%)
* Lighting: 50% Energy Star permanent CFL or fluorescent lamps
* HVAC system: SEER 13 AC and 0.78 AFUE furnace
* DHW: 0.59 EF NG heater
* Duct Location: Unconditioned, vented attic
* Duct Leakage to Outdoor: 8 cfm/100 sq-ft CFA

NOx REDUCTIONS FROM CODE COMPLIANT CONSTRUCTION - VALIDATION

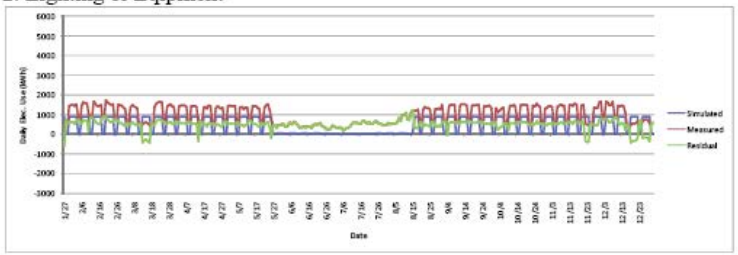
NOx REDUCTIONS FROM CODE COMPLIANT CONSTRUCTION - VALIDATION

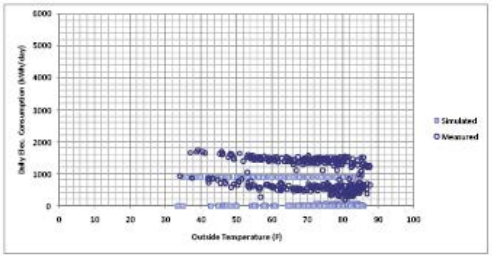
NOx REDUCTIONS FROM CODE COMPLIANT CONSTRUCTION - VALIDATION





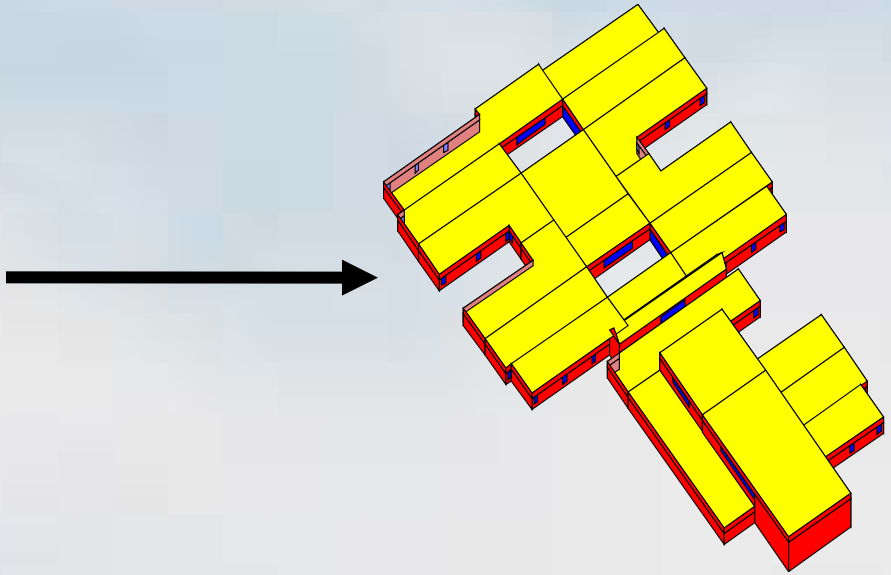
2. Lighting & Eqipment



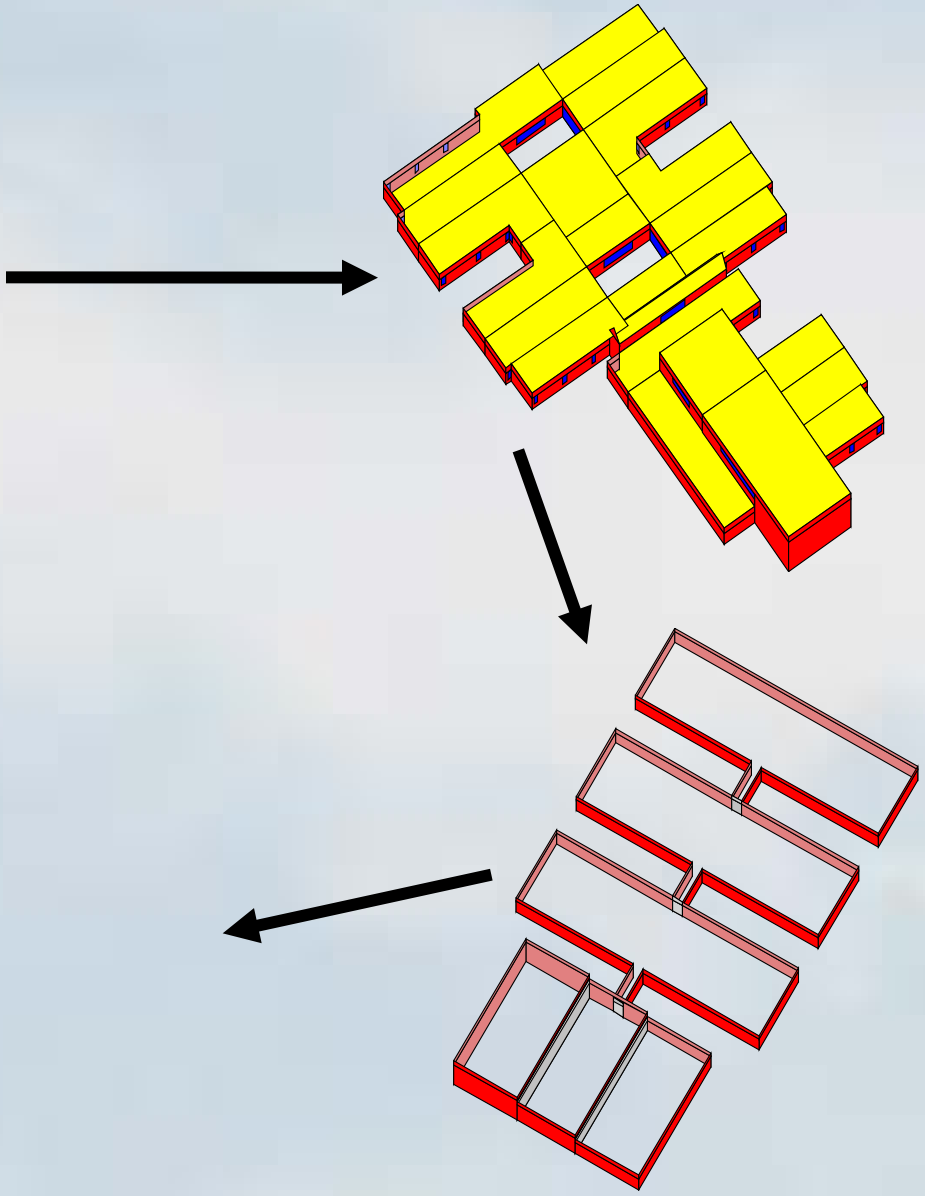


NOx REDUCTIONS FROM CODE COMPLIANT CONSTRUCTION – NEW TOOLS

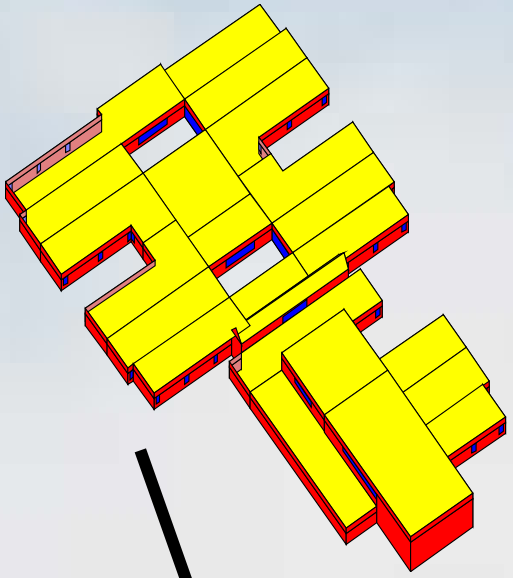
NOx REDUCTIONS FROM CODE COMPLIANT CONSTRUCTION – NEW TOOLS

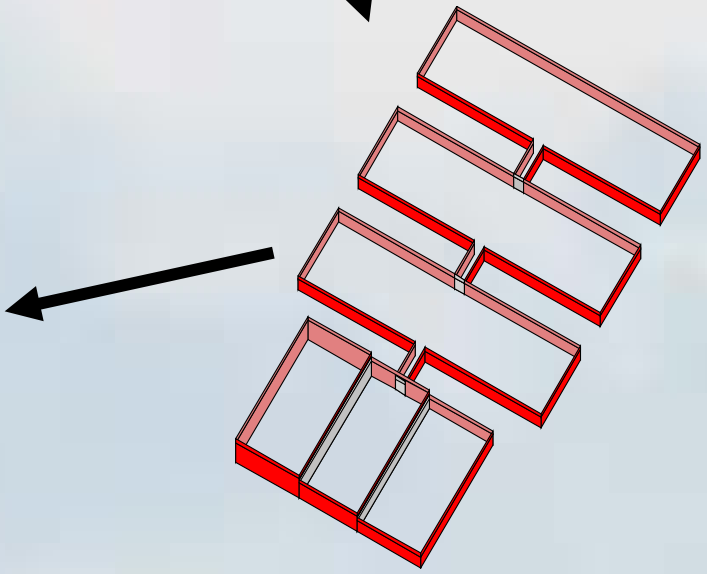


NOx REDUCTIONS FROM CODE COMPLIANT CONSTRUCTION – NEW TOOLS

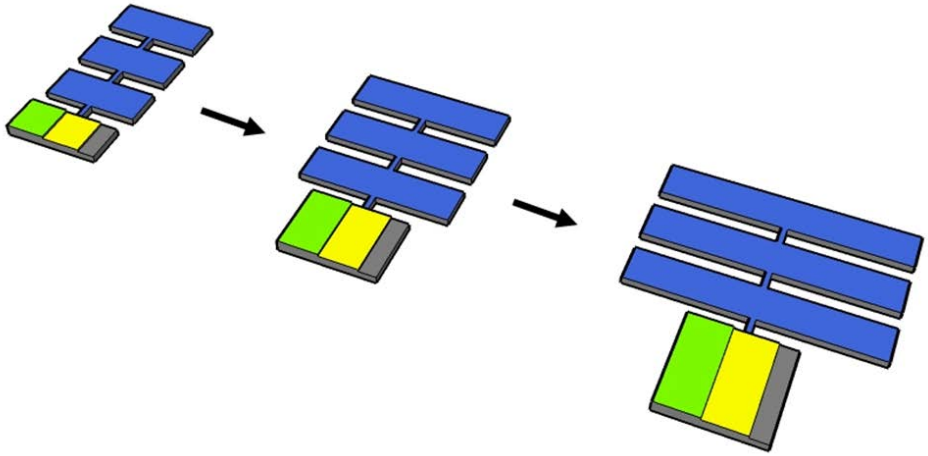


NOx REDUCTIONS FROM CODE COMPLIANT CONSTRUCTION – NEW TOOLS



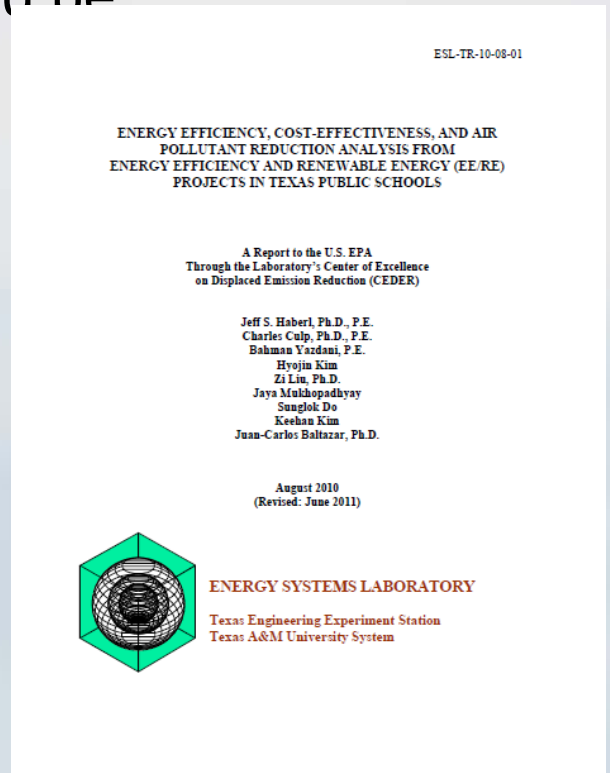


Web-based K-12 tool



EE/RE IN TEXAS SCHOOLS

- In 2010 the U.S.E.P.A. requested a study to see how much energy/emissions could be saved if all schools in Texas were upgraded to new energy code.
- 18 EE/RE Measures were reviewed.
- Total energy and emissions savings if applied to all new and existing Texas ISDs (700.3 million ft^2) would be:



ESL-TR-10-08-01

ENERGY EFFICIENCY, COST-EFFECTIVENESS, AND AIR POLLUTANT REDUCTION ANALYSIS FROM ENERGY EFFICIENCY AND RENEWABLE ENERGY (EE/RE) PROJECTS IN TEXAS PUBLIC SCHOOLS

A Report to the U.S. EPA
Through the Laboratory's Center of Excellence
on Displaced Emission Reduction (CEDER)

Jeff S. Haberl, Ph.D., P.E.
Charles Culp, Ph.D., P.E.
Bahman Yazdani, P.E.
Hyojin Kim
Zi Liu, Ph.D.
Jaya Mukhopadhyay
Sunglok Do
Keehan Kim
Juan-Carlos Baltazar, Ph.D.

August 2010
(Revised: June 2011)

ENERGY SYSTEMS LABORATORY
Texas Engineering Experiment Station
Texas A&M University System

EE/RE IN TEXAS SCHOOLS

- In 2010 the U.S.E.P.A. requested a study to see how much energy/emissions could be saved if all schools in Texas were upgraded to new energy code.
- 18 EE/RE Measures were reviewed.
- Total energy and emissions savings if applied to all new and existing Texas ISDs (700.3 million ft^2) would be:

10,520,419 MMBtu/yr (Elec: $338 million/yr)*

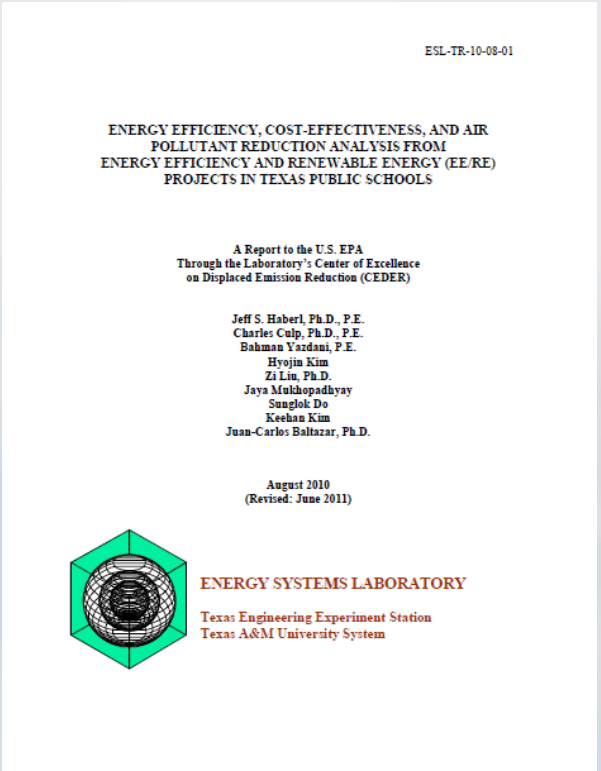
-12,172,811 MMBtu/yr (N.G. -$10 million/yr)

2,743 tons/yr for Nox (6.0 tons/OSD)

1,772 tons/yr for SO_2

2,286,012 tons/yr for CO_2

* Note $0.095/kWh, $0.65/therm



ESL-TR-10-08-01

ENERGY EFFICIENCY, COST-EFFECTIVENESS, AND AIR POLLUTANT REDUCTION ANALYSIS FROM ENERGY EFFICIENCY AND RENEWABLE ENERGY (EE/RE) PROJECTS IN TEXAS PUBLIC SCHOOLS

A Report to the U.S. EPA
Through the Laboratory's Center of Excellence
on Displaced Emission Reduction (CEDER)

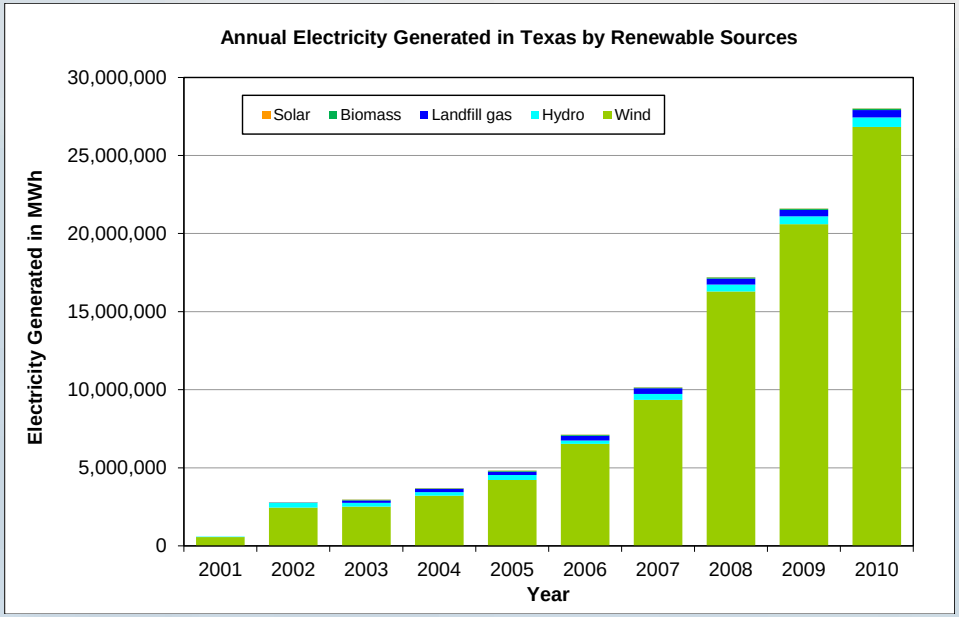
Jeff S. Haberl, Ph.D., P.E.
Charles Culp, Ph.D., P.E.
Bahman Yazdani, P.E.
Hyojin Kim
Zi Liu, Ph.D.
Jaya Mukhopadhyay
Sunglok Do
Keehan Kim
Juan-Carlos Baltazar, Ph.D.

August 2010
(Revised: June 2011)

ENERGY SYSTEMS LABORATORY
Texas Engineering Experiment Station
Texas A&M University System

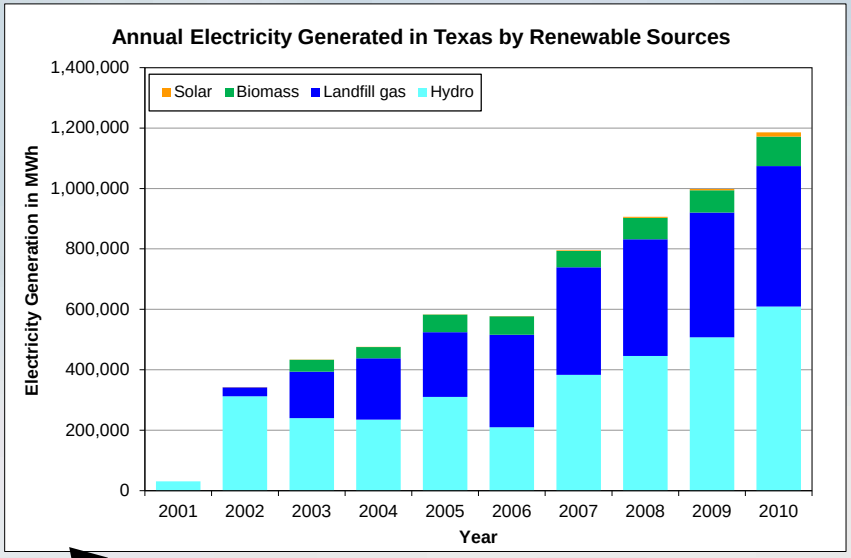
RENEWABLES: WHAT ARE THEY?

Wind energy is the largest portion.

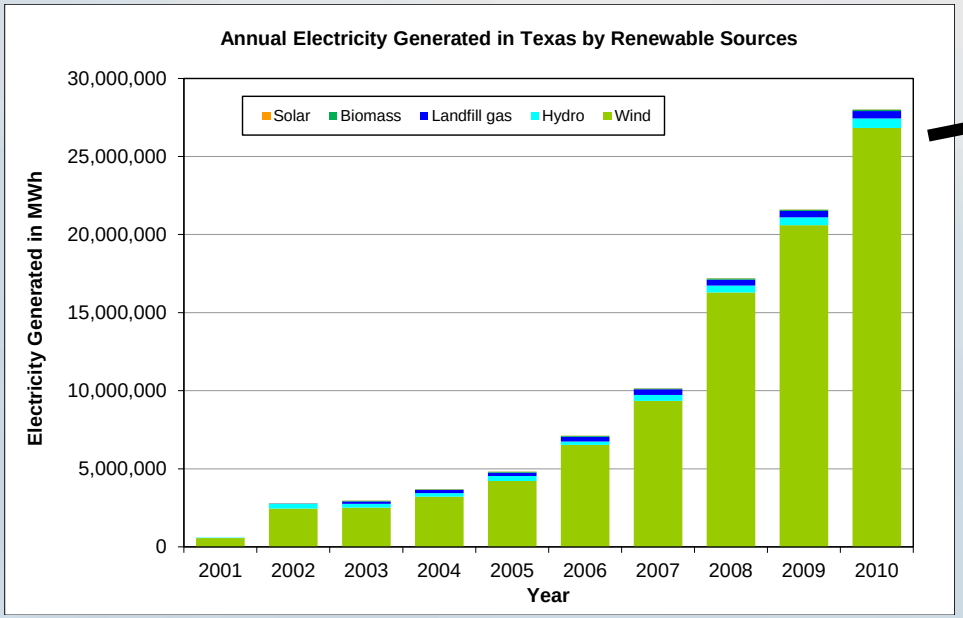


RENEWABLES: WHAT ARE THEY?

Landfill gas, hydro are next.

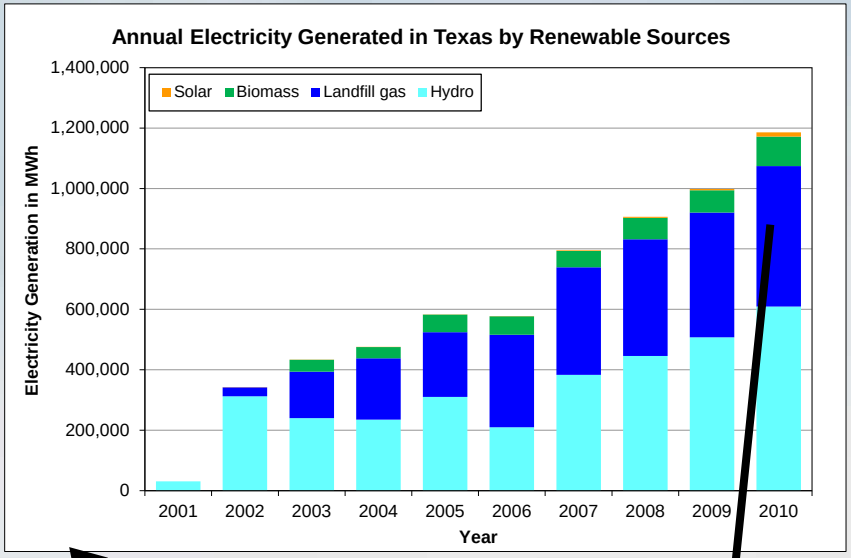


Wind energy is the largest portion.

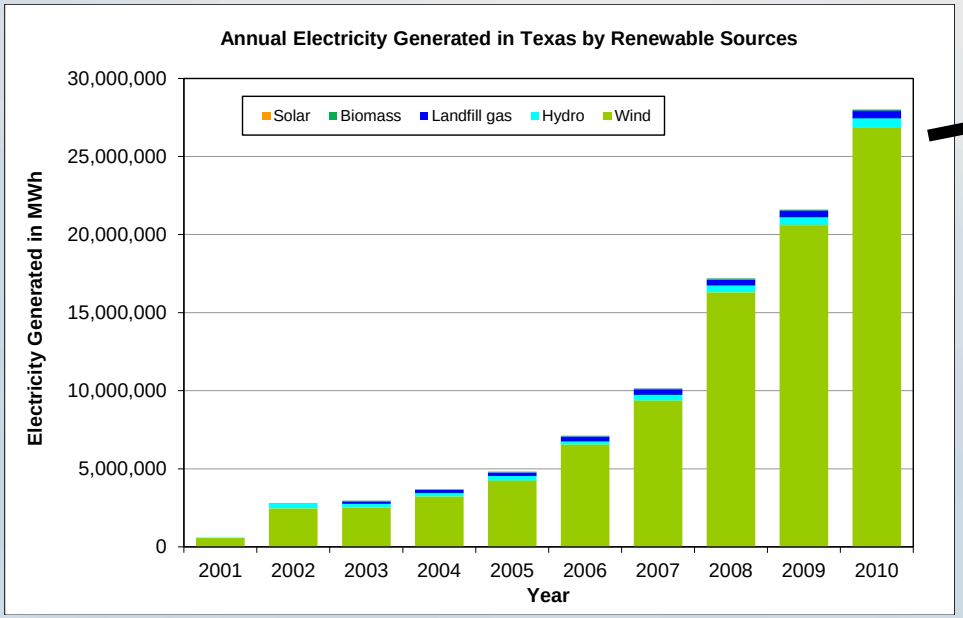


RENEWABLES: WHAT ARE THEY?

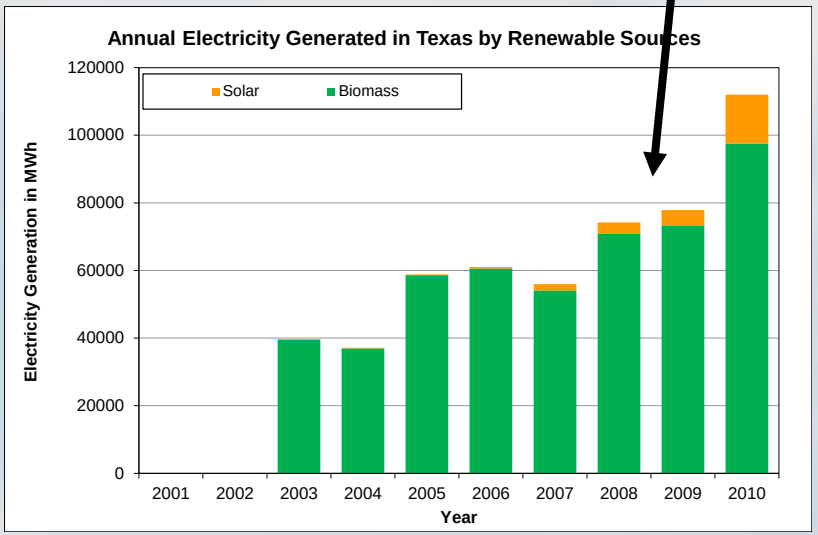
Landfill gas, hydro are next.



Wind energy is the largest portion.

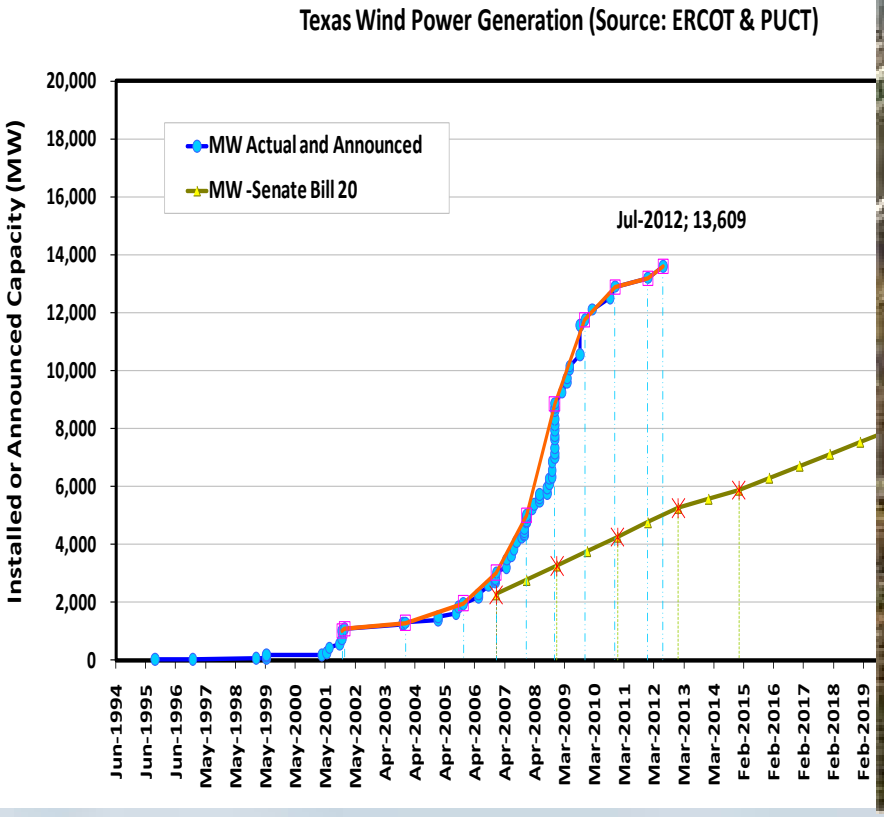


Biomass, solar are smallest

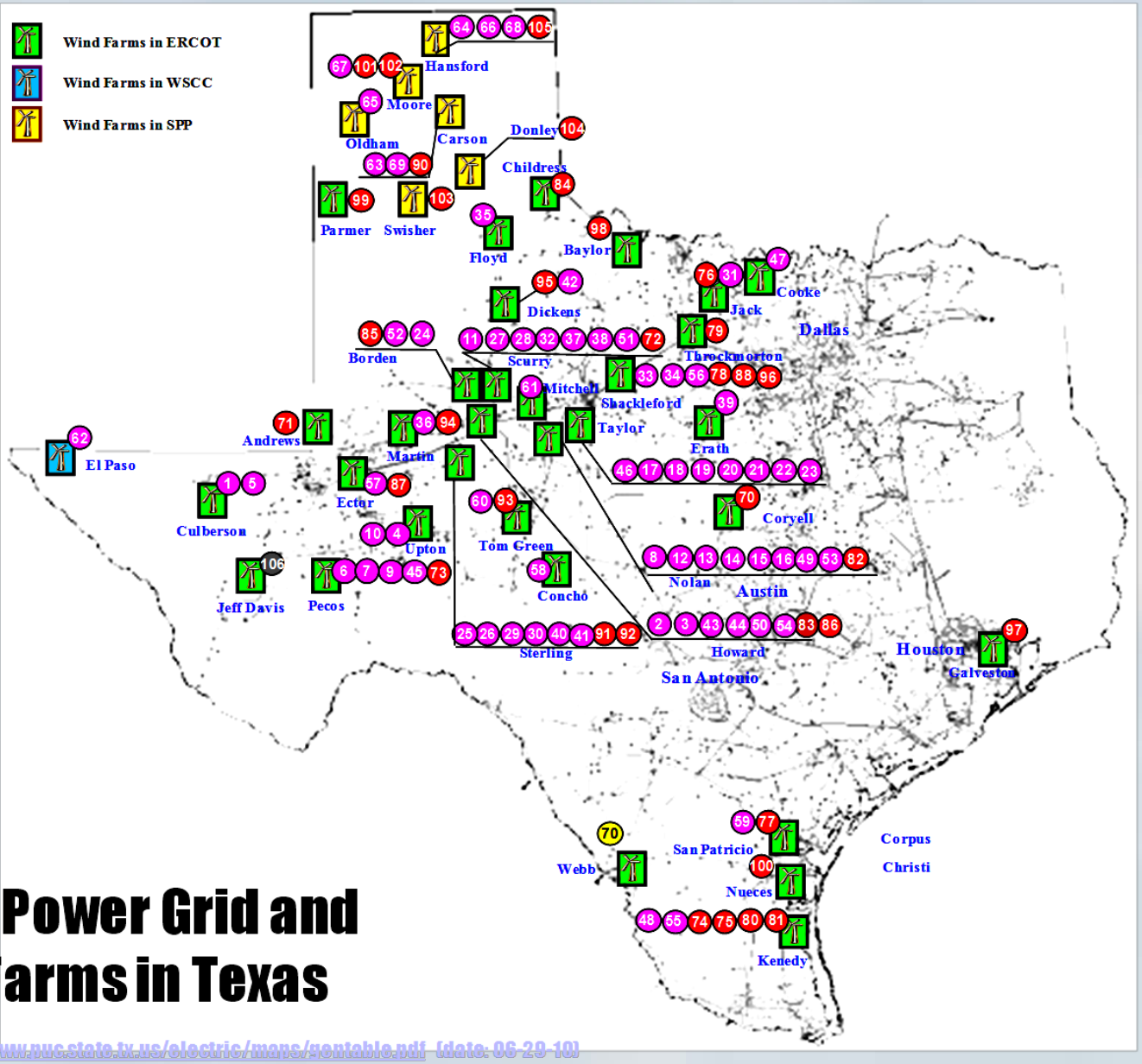


WIND PROJECTS IN TEXAS

Wind energy farms coming on-line ahead of legislative goals.



WIND PROJECTS IN TEXAS

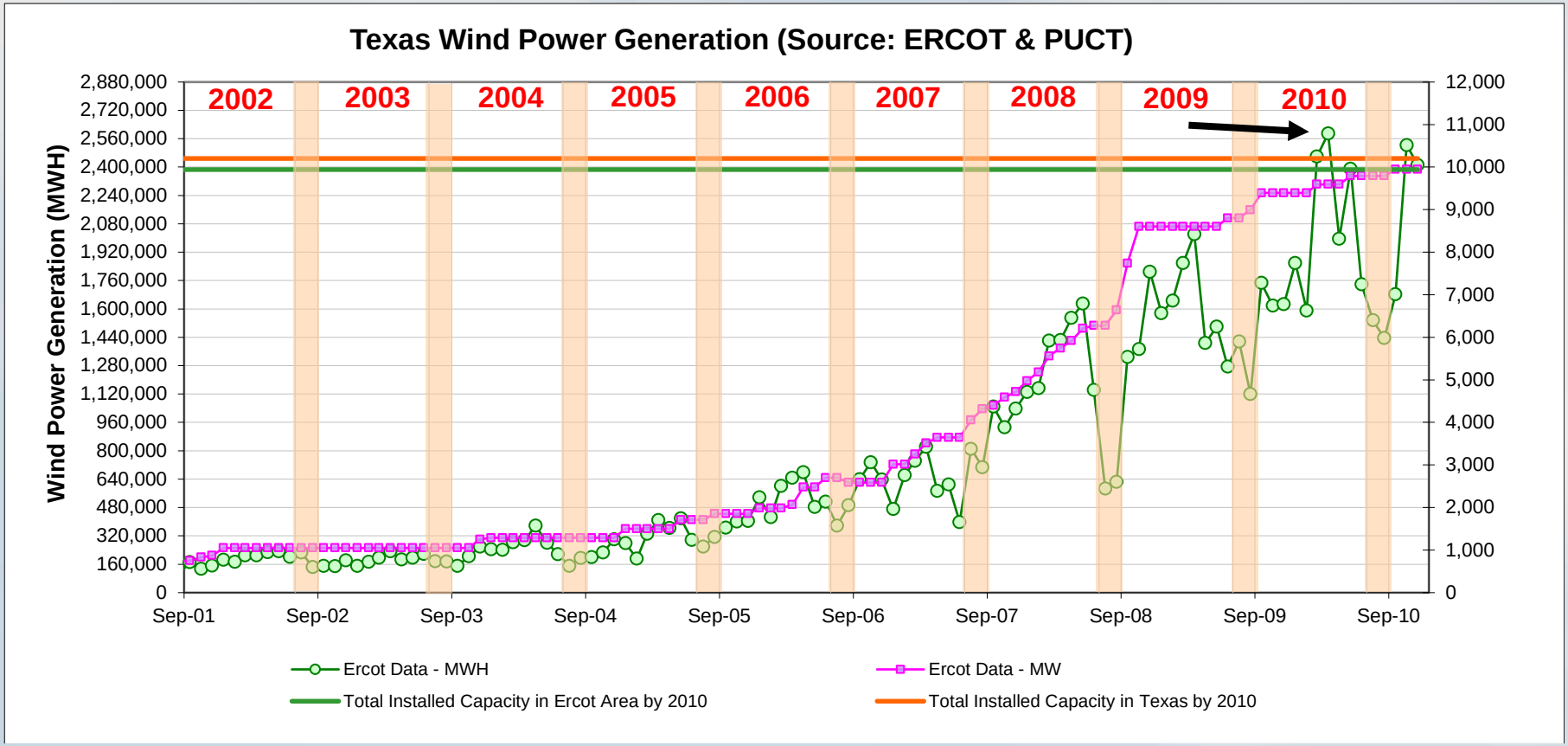


ERCOT Power Grid and Wind Farms in Texas

Source: http://www.puc.state.tx.us/electric/maps/gentable.pdf (date: 06-29-10)

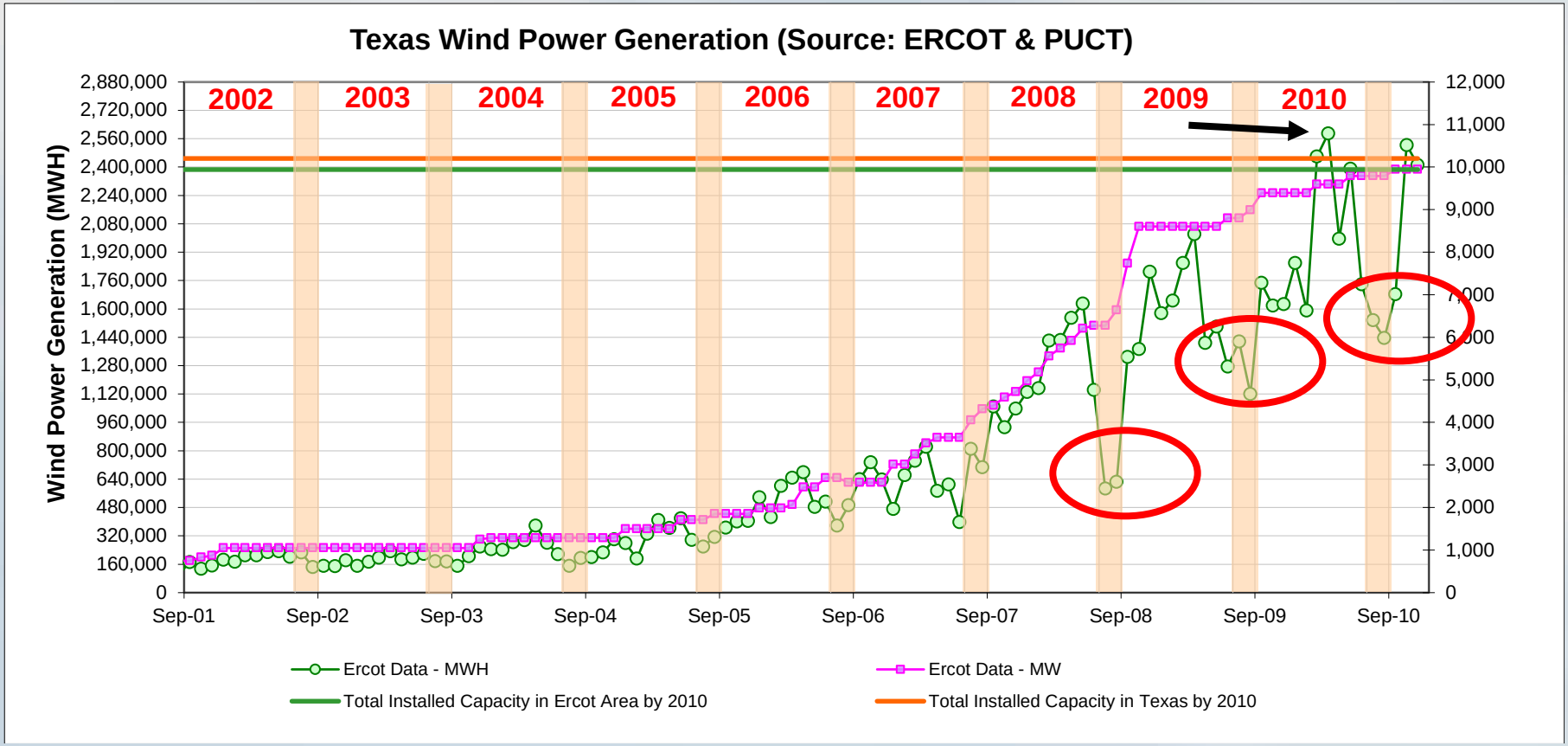
WIND PROJECTS IN TEXAS (2010)

Substantial increases in measured electricity from wind energy.



WIND PROJECTS IN TEXAS (2010)

Substantial increases in measured electricity from wind energy.

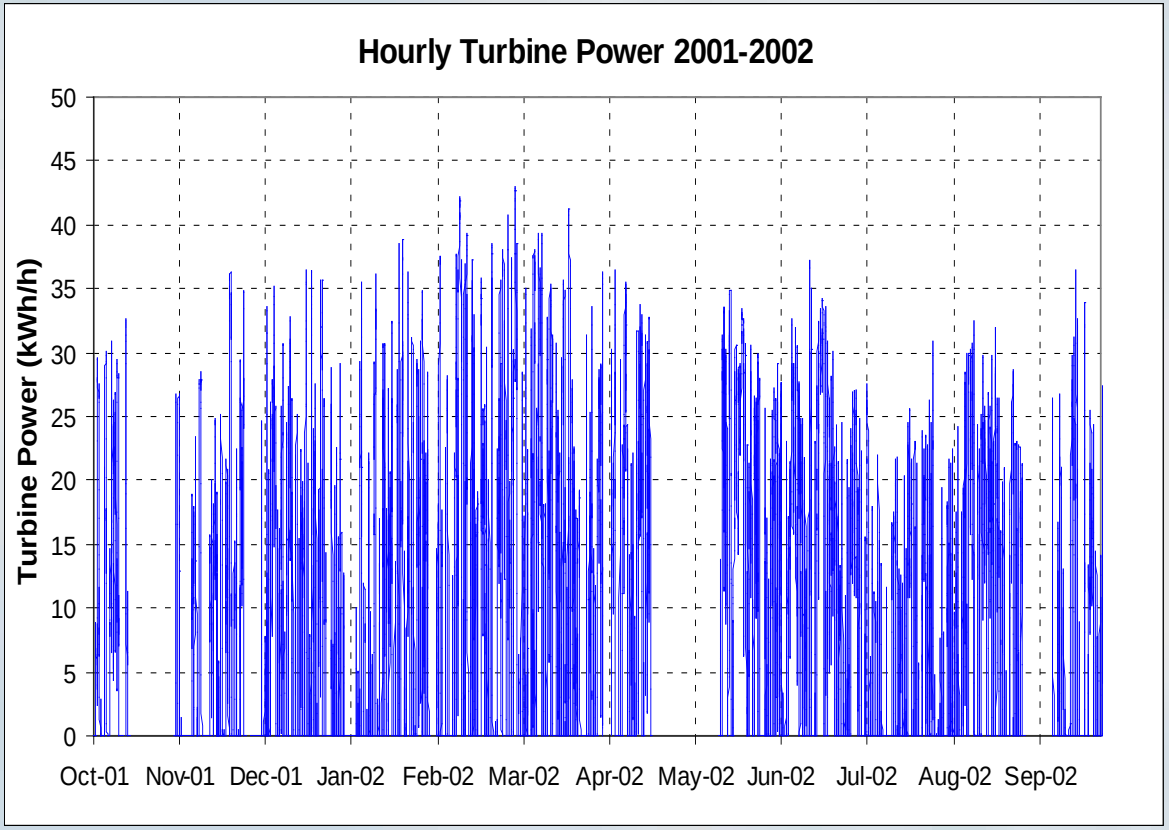


However, wind generation during Ozone Season Period less than other periods.

METHODOLOGY: WIND ENERGY

How Was The Wind Energy Production Weather Normalized? Tested?

- The measured, hourly electricity produced by the wind turbine is shown for the 2001/2002 period.
- Data for this site was provided by Alternative Energy Institute from West Texas A&M University.

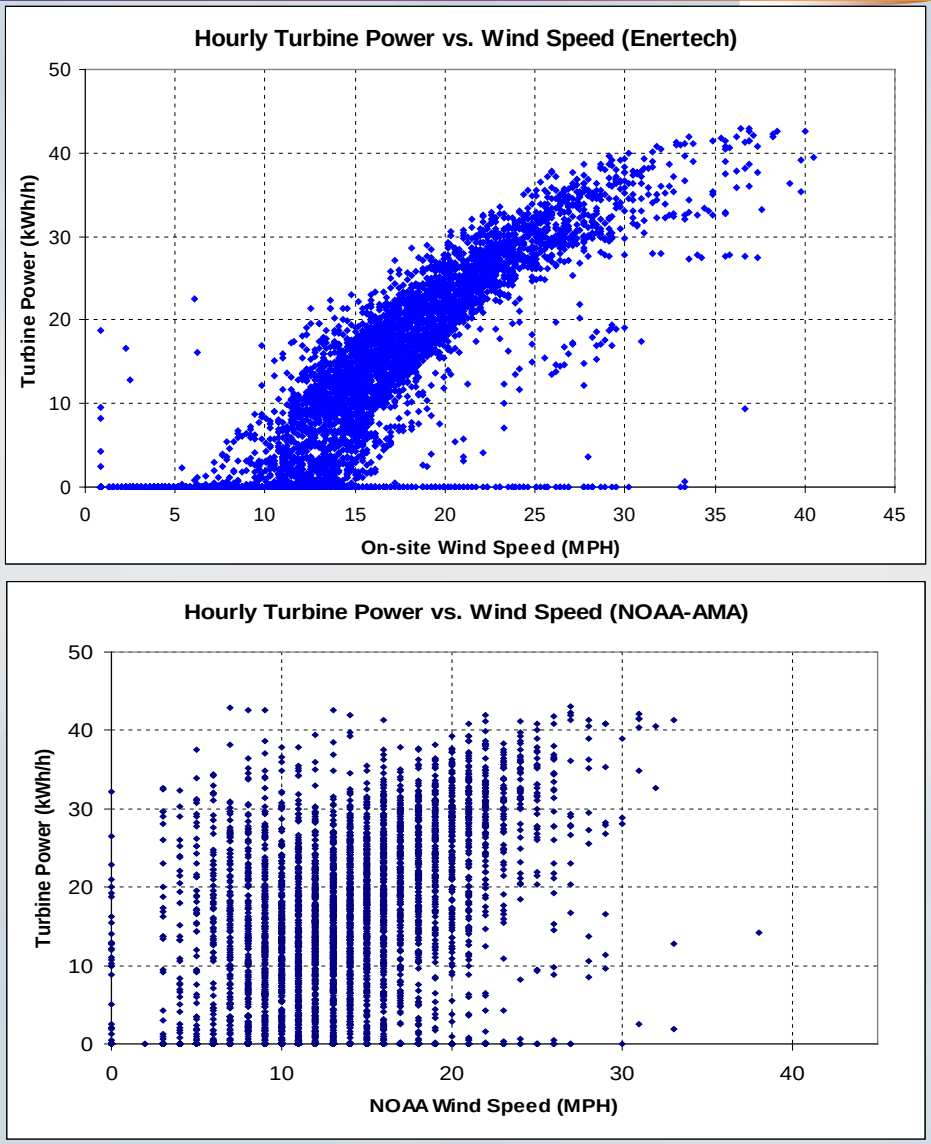


Measured Hourly Turbine Power (2001-2002)

METHODOLOGY: WIND ENERGY

Wind Power Generation Data Analysis:

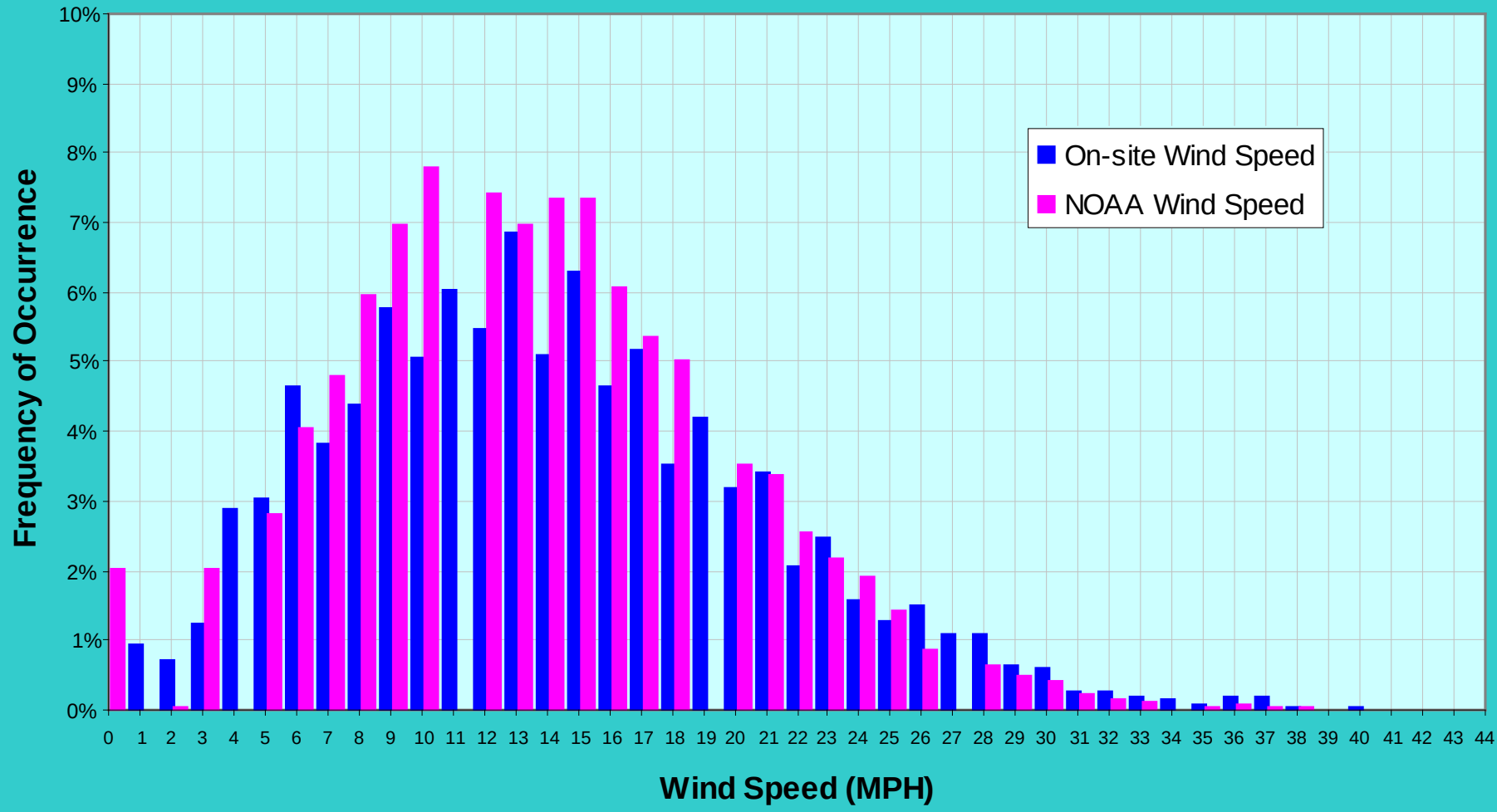
- Normally, hourly performance is evaluated using hourly on-site wind measurements.
- Unfortunately, hourly measurements for 1999 to 2005 unavailable for this site.
- Therefore, evaluation made using nearby NWS hourly wind measurements.



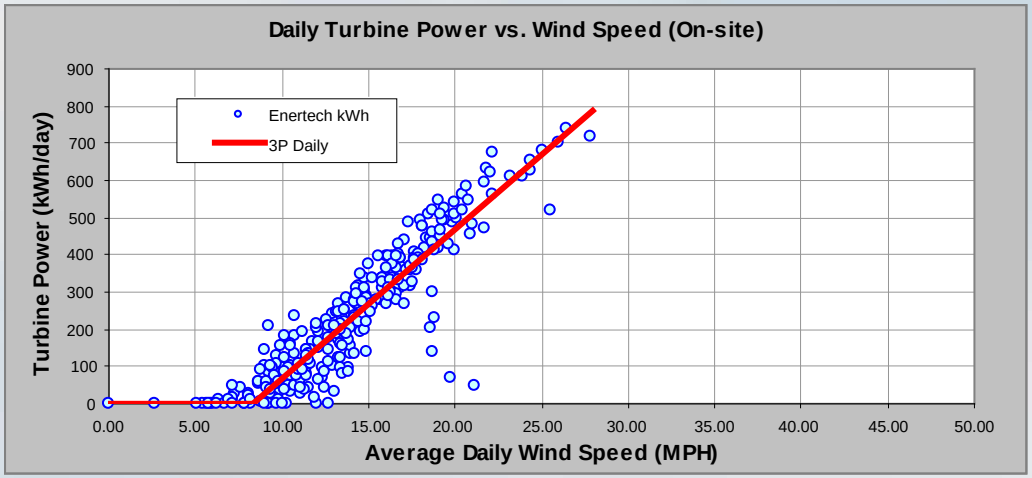
Hourly Turbine Power vs. NOAA and On-site Wind Speed

METHODOLOGY: WIND ENERGY

Comparison of On-Site and NOAA Wind Speed:



METHODOLOGY: WIND ENERGY

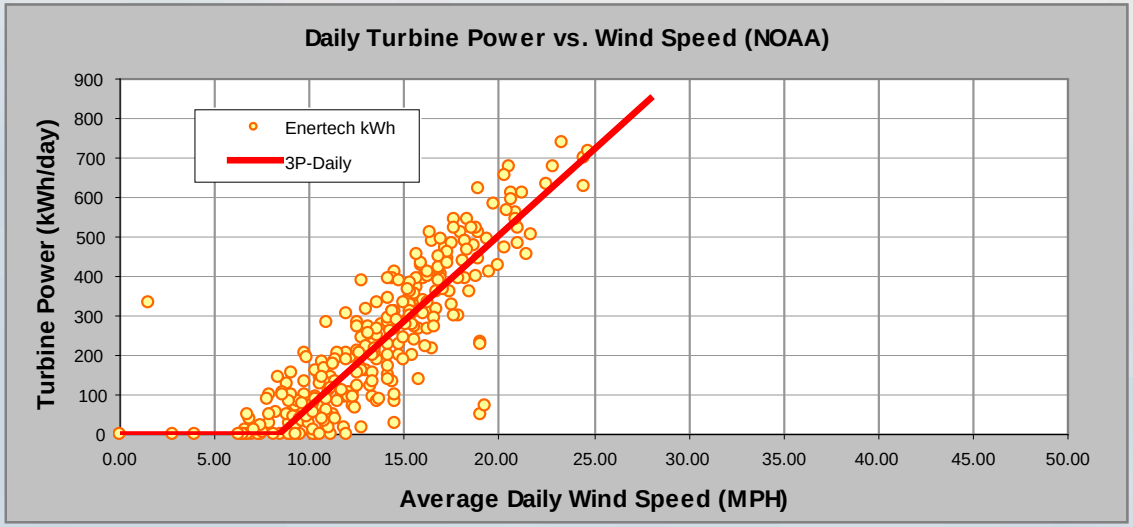


Modeled daily electricity vs daily wind data (on-site vs NOAA).

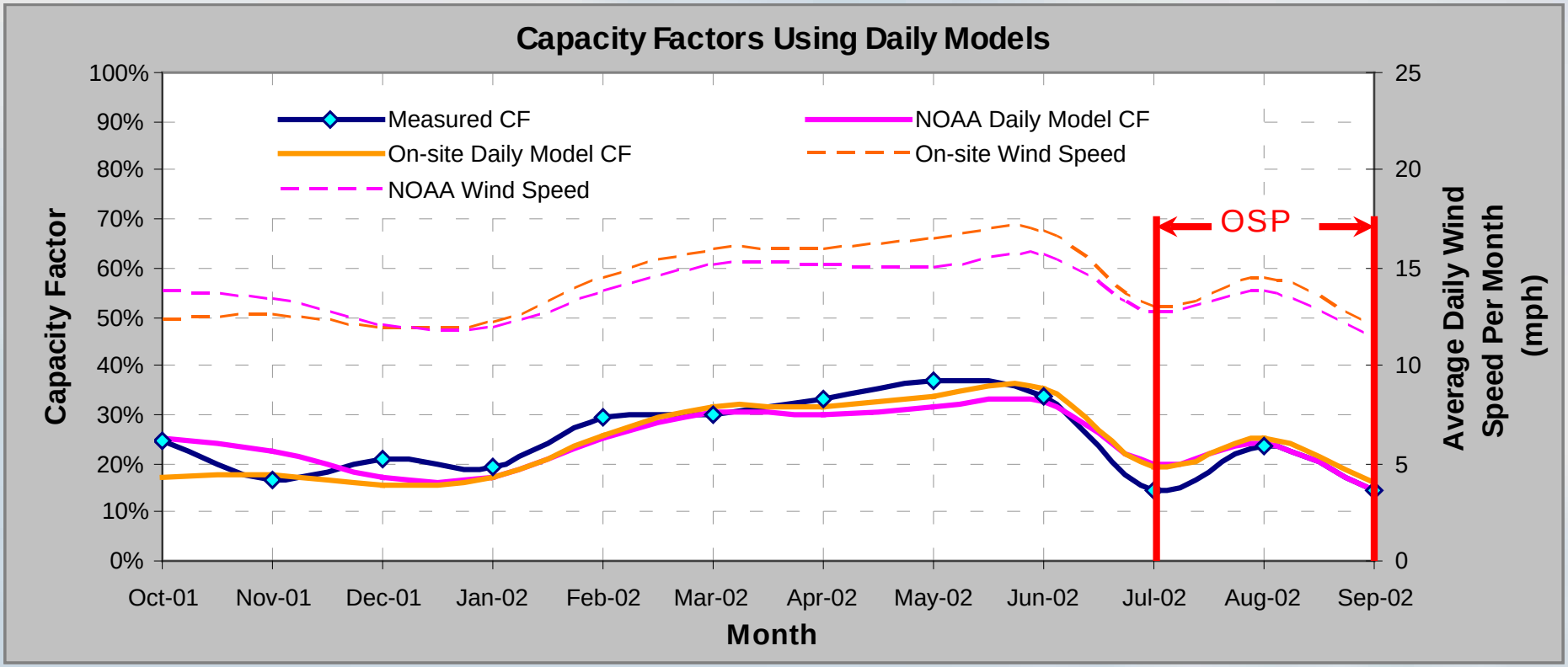
Result: on-site, 3P CP on-site model, acceptable.

Modeled daily electricity vs daily wind data (NOAA)

Result: 3P CP NOAA model also acceptable.



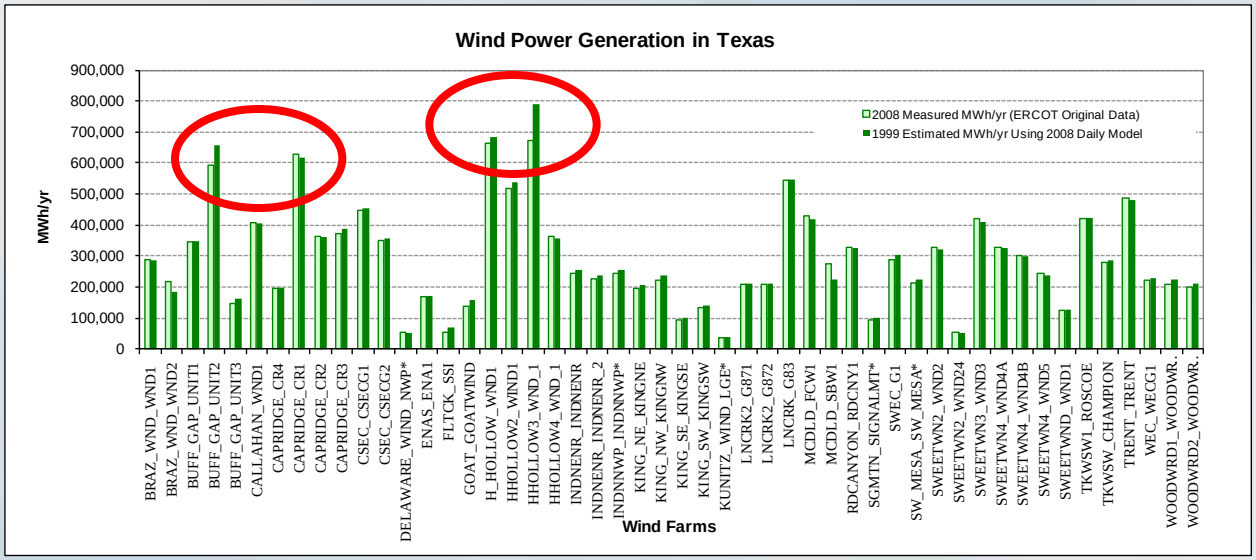
METHODOLOGY: WIND ENERGY



Next, compared NOAA and on-site daily models to see how well the predicted OSP electricity production. (Result: acceptable).

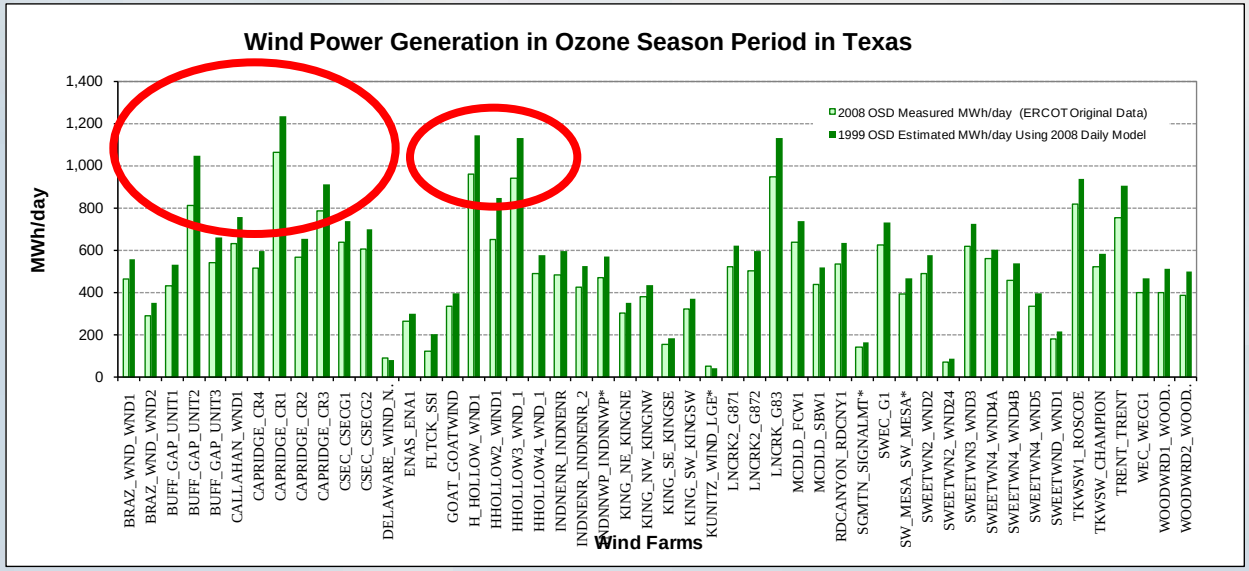
RESULTS: WIND ANALYSIS – ALL SITES

Method Developed to Analyze Total Wind Production in 2009.



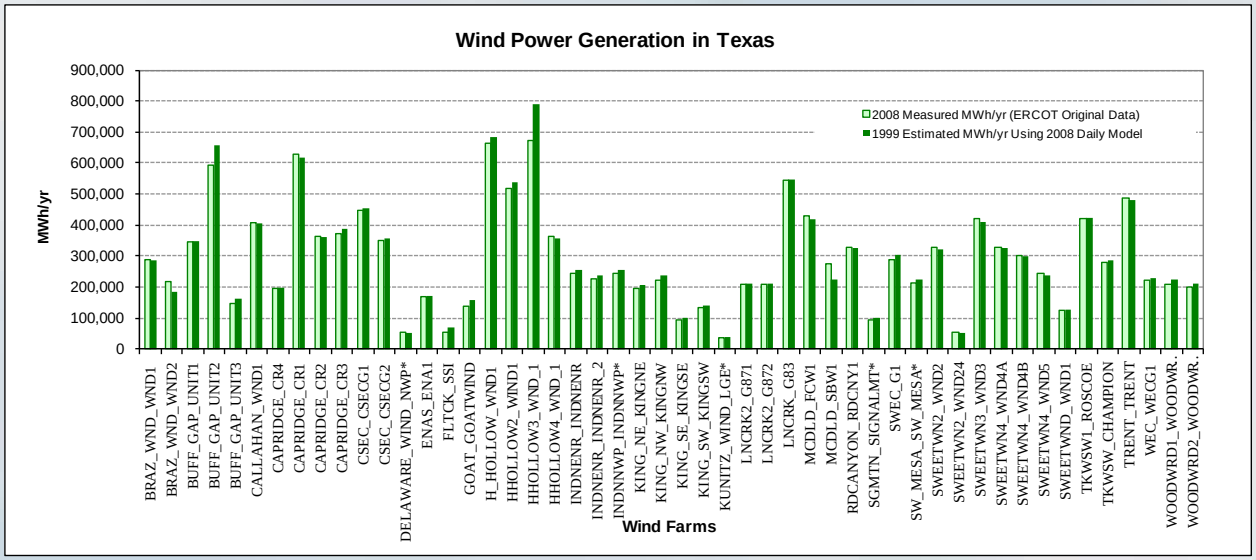
Results:

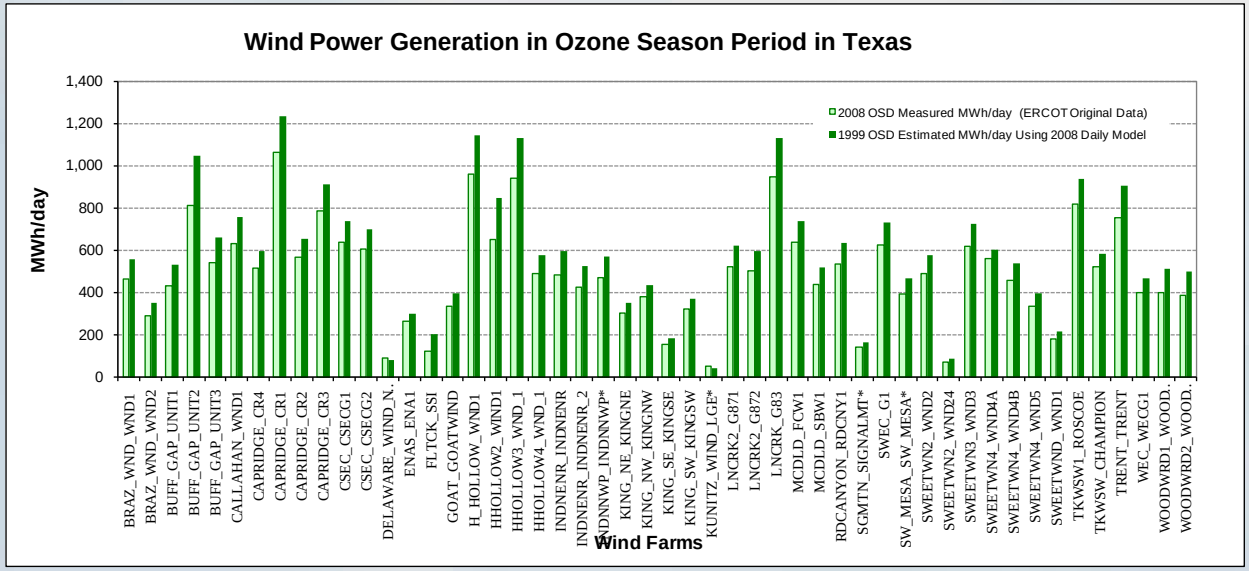
Weather-normalizing to 1999 and 2007 eGRID produces more accurate savings.



RESULTS: WIND ANALYSIS – ALL SITES

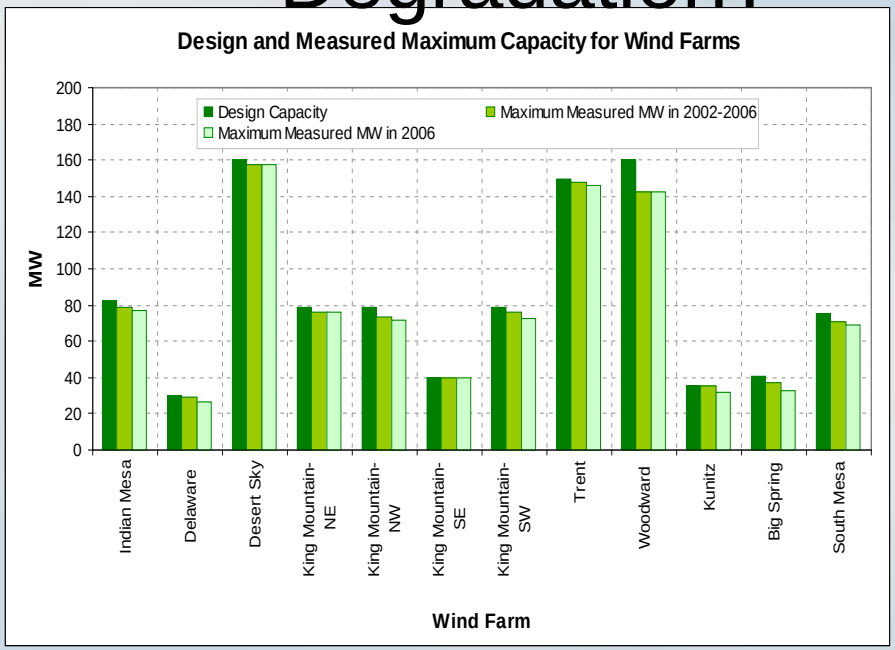
Method Developed to Analyze Total Wind Production in 2009.



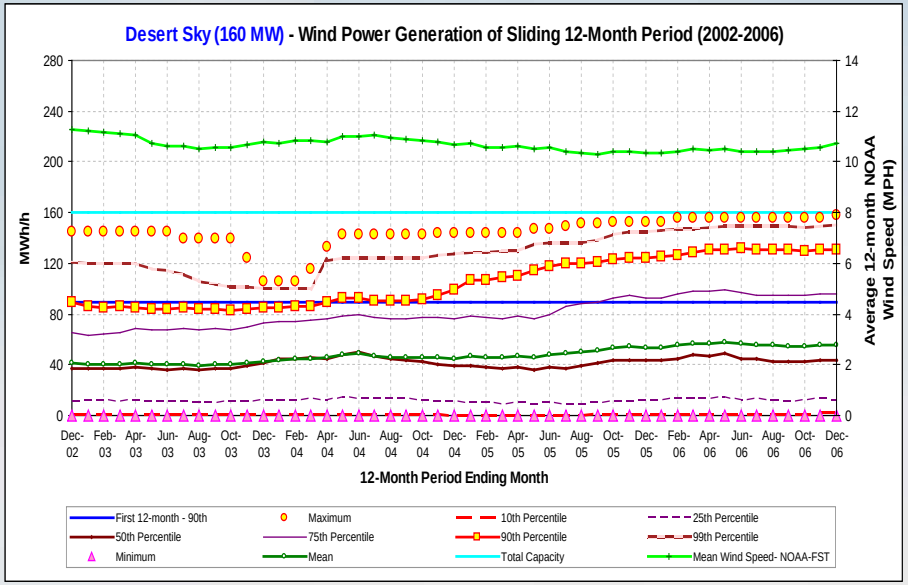


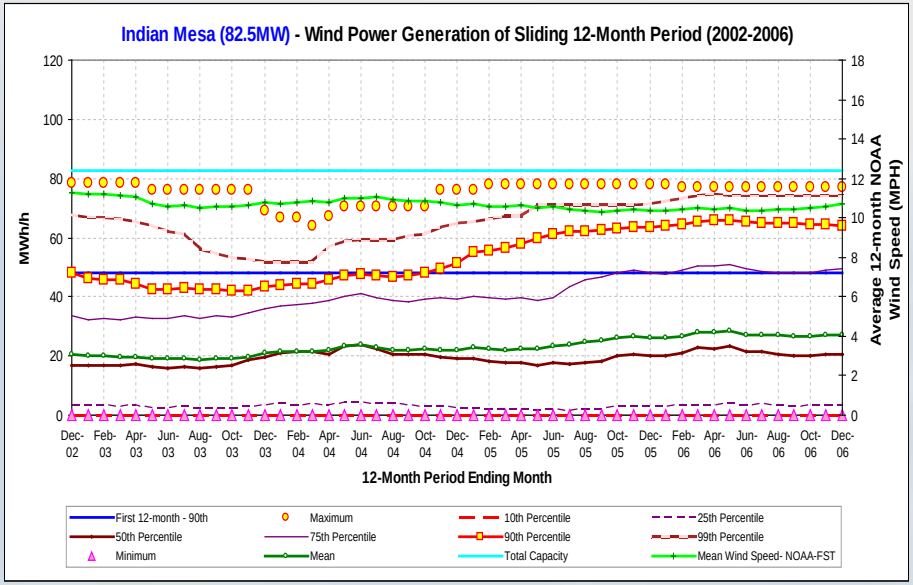
ISSUES: WIND ANALYSIS

Degradation?



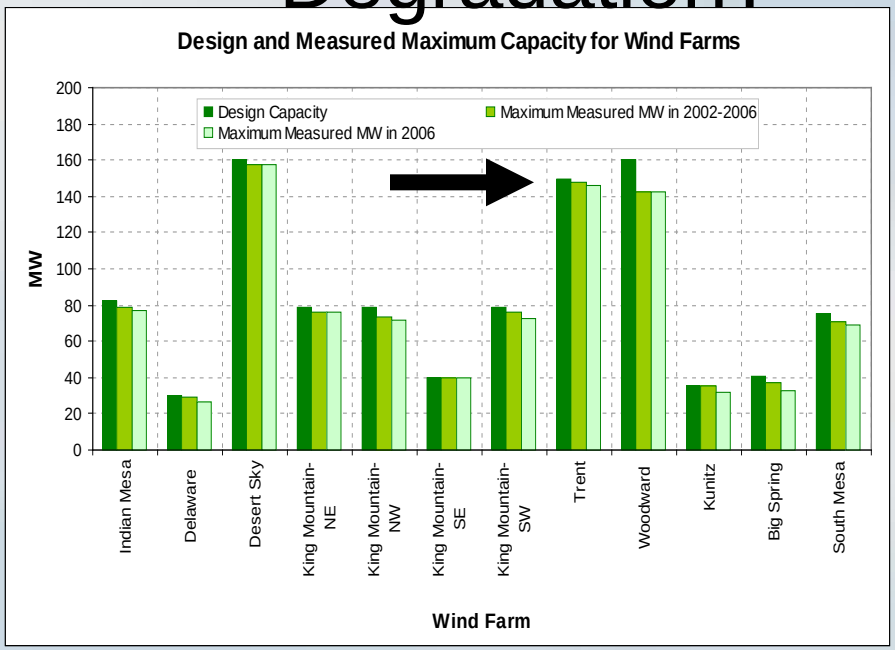
Wind Farm	First 12-mo 90th Percentile Hourly Wind Power		Average of the Sliding 12-mo 90th Precentile Hourly Wind Power		Minimum of the Sliding 12-mo 90th Precentile Hourly Wind Power		Maximum of the Sliding 12-mo 90th Precentile Hourly Wind Power		No. of Month of Data	Capacity (MW)
	First 12-mo Ending Mo.	MW	MW	% Diff. vs. First 12-mo	MW	% Diff. vs. First 12-mo	MW	% Diff. vs. First 12-mo		
Indian Mesa	Dec-02	48.0	53.8	12.1%	42.1	-12.2%	66.0	37.5%	60	82.5
Delaware	Dec-02	18.6	19.3	4.2%	15.6	-15.8%	21.5	15.7%	60	30
Desert Sky	Dec-02	89.0	105.0	17.9%	83.1	-6.7%	131.3	47.5%	60	160
King Mountain-NE	Dec-02	41.8	43.9	4.9%	36.3	-13.2%	52.5	25.5%	60	79
King Mountain-NW	Dec-02	44.7	49.4	10.5%	40.2	-10.1%	62.3	39.3%	60	79
King Mountain-SE	Dec-02	21.6	22.1	2.0%	18.4	-15.0%	25.8	19.1%	60	40
King Mountain-SW	Dec-02	41.6	45.2	8.7%	38.4	-7.6%	53.4	28.5%	60	79
Trent	Dec-02	108.8	125.2	15.1%	108.2	-0.6%	132.8	22.0%	60	150
Woodward	Dec-02	85.3	90.8	6.5%	80.4	-5.7%	100.3	17.6%	60	160
Kunitz	Dec-02	25.2	22.2	-11.8%	18.3	-27.1%	25.2	0.0%	60	35
Big Spring	Dec-02	27.2	25.6	-5.9%	23.9	-12.0%	27.2	0.0%	60	41
Southwest Mesa	Dec-02	51.1	46.7	-8.6%	38.5	-24.6%	55.3	8.2%	60	75
Weighted Average:				7.9%		-9.8%		25.8%	Total:	1010.5

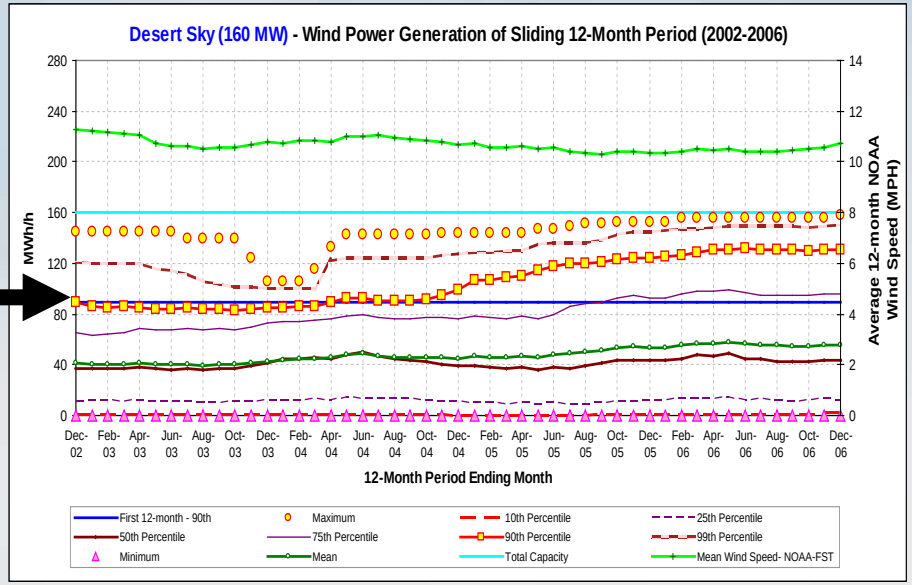


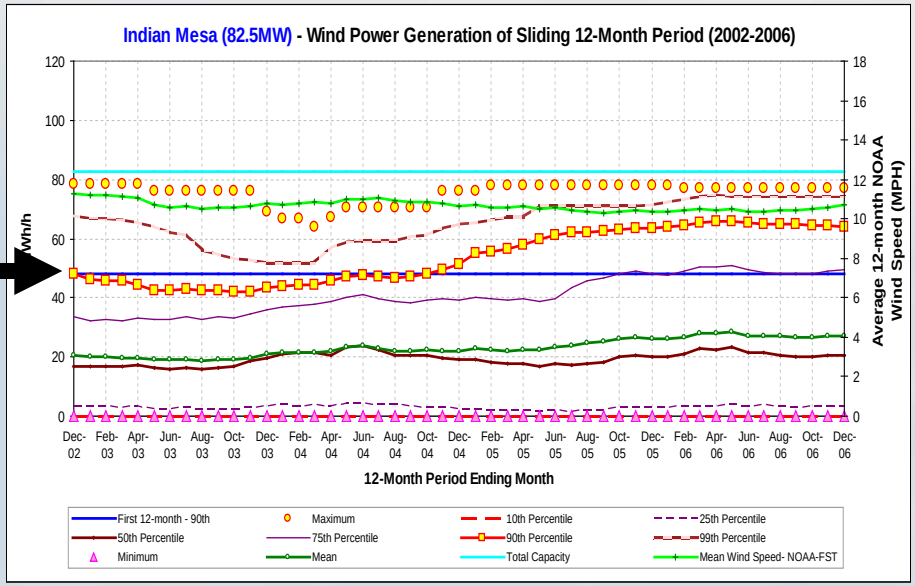


ISSUES: WIND ANALYSIS

Degradation?



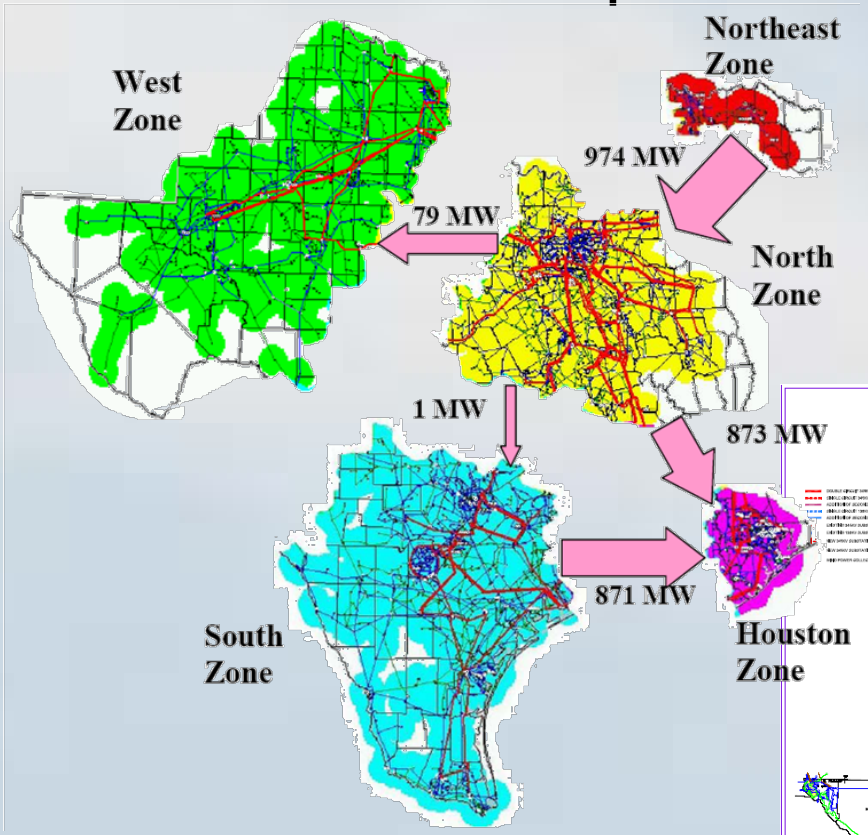


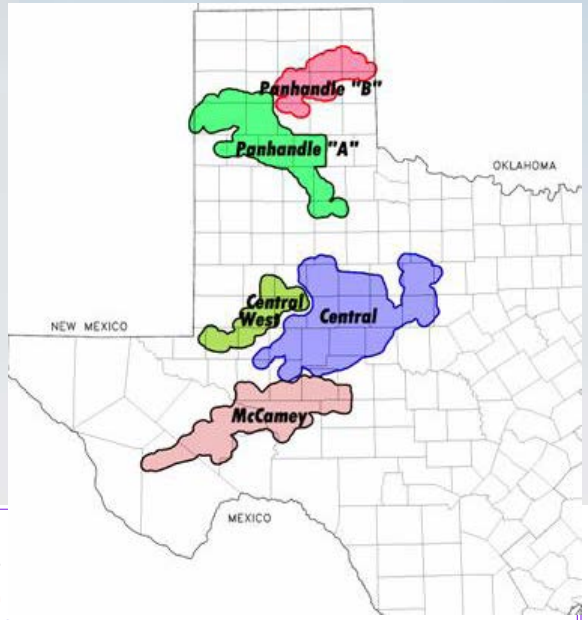


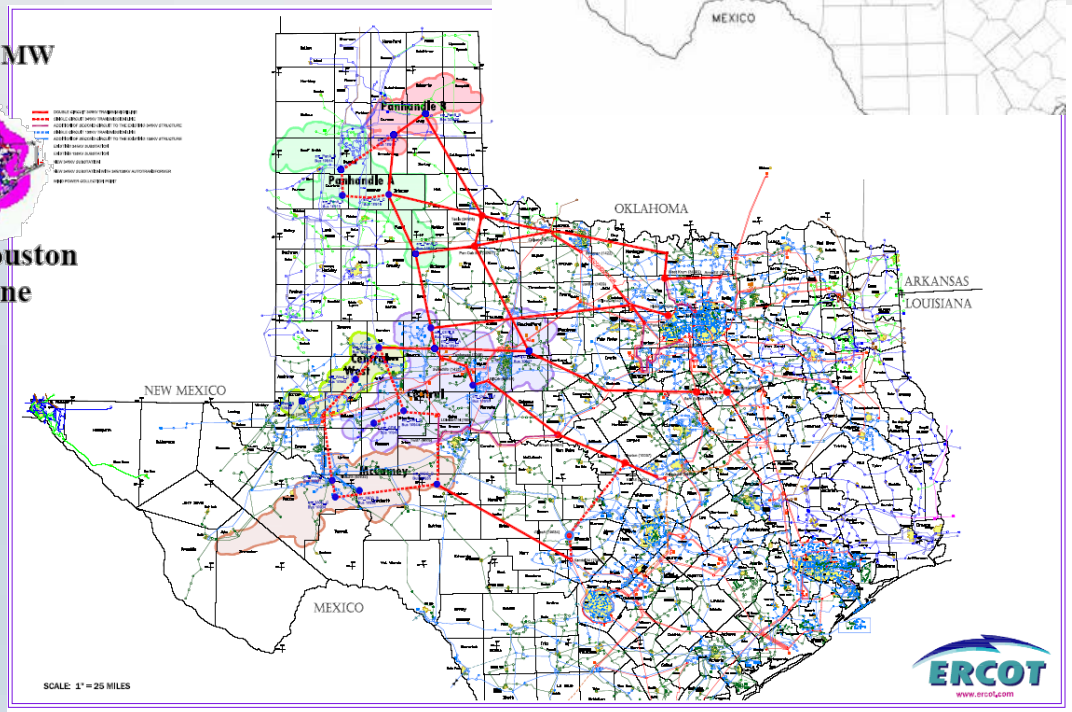
Wind Farm	First 12-mo 90th Percentile Hourly Wind Power		Average of the Sliding 12-mo 90th Precentile Hourly Wind Power		Minimum of the Sliding 12-mo 90th Precentile Hourly Wind Power		Maximum of the Sliding 12-mo 90th Precentile Hourly Wind Power		No. of Month of Data	Capacity (MW)
	First 12-mo Ending Mo.	MW	MW	% Diff. vs. First 12-mo	MW	% Diff. vs. First 12-mo	MW	% Diff. vs. First 12-mo		
Indian Mesa	Dec-02	48.0	53.8	12.1%	42.1	-12.2%	66.0	37.5%	60	82.5
Delaware	Dec-02	18.6	19.3	4.2%	15.6	-15.8%	21.5	15.7%	60	30
Desert Sky	Dec-02	89.0	105.0	17.9%	83.1	-6.7%	131.3	47.5%	60	160
King Mountain-NE	Dec-02	41.8	43.9	4.9%	36.3	-13.2%	52.5	25.5%	60	79
King Mountain-NW	Dec-02	44.7	49.4	10.5%	40.2	-10.1%	62.3	39.3%	60	79
King Mountain-SE	Dec-02	21.6	22.1	2.0%	18.4	-15.0%	25.8	19.1%	60	40
King Mountain-SW	Dec-02	41.6	45.2	8.7%	38.4	-7.6%	53.4	28.5%	60	79
Trent	Dec-02	108.8	125.2	15.1%	108.2	-0.6%	132.8	22.0%	60	150
Woodward	Dec-02	85.3	90.8	6.5%	80.4	-5.7%	100.3	17.6%	60	160
Kunitz	Dec-02	25.2	22.2	-11.8%	18.3	-27.1%	25.2	0.0%	60	35
Big Spring	Dec-02	27.2	25.6	-5.9%	23.9	-12.0%	27.2	0.0%	60	41
Southwest Mesa	Dec-02	51.1	46.7	-8.6%	38.5	-24.6%	55.3	8.2%	60	75
Weighted Average:				7.9%		-9.8%		25.8%	Total:	1010.5

ISSUES: WIND ANALYSIS

Distribution of power on the grid?

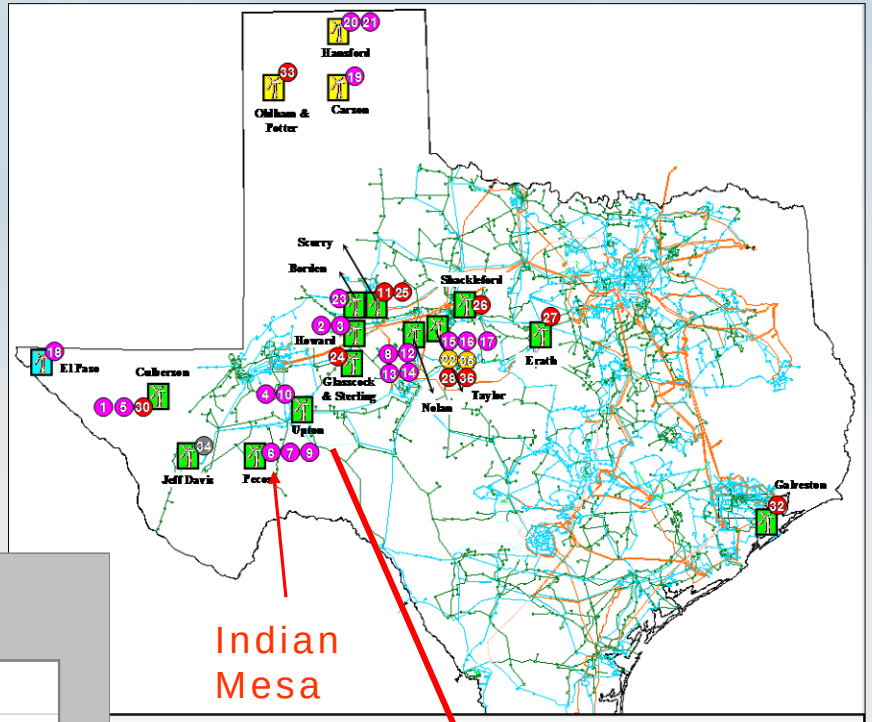


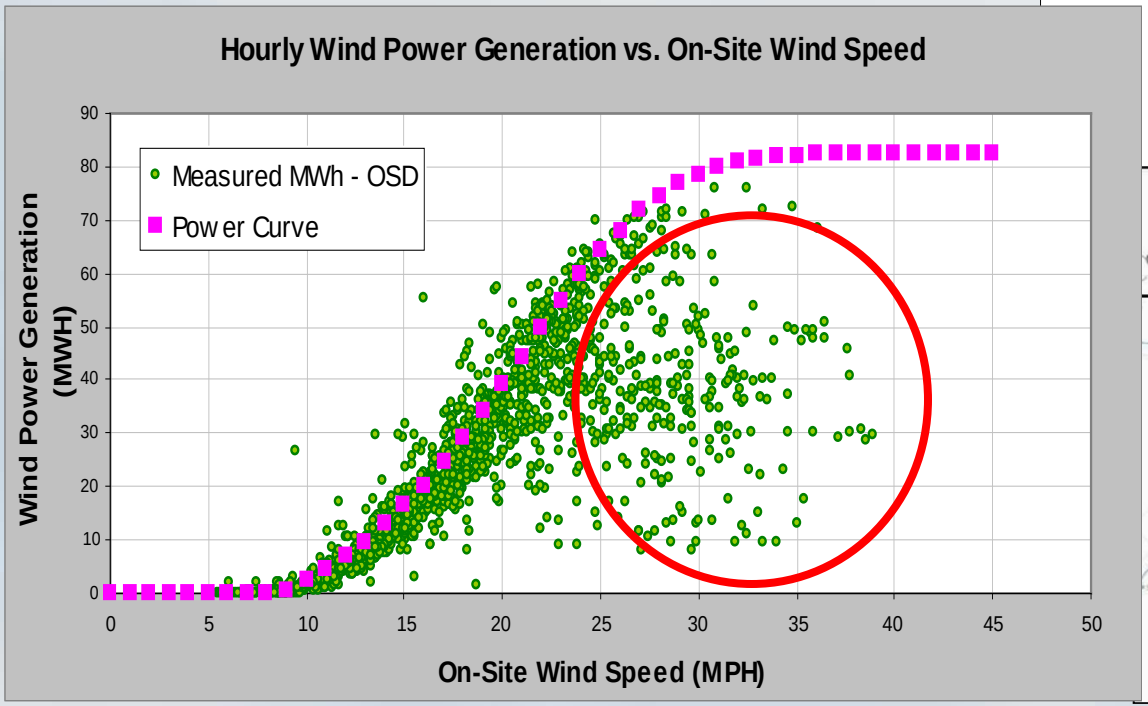


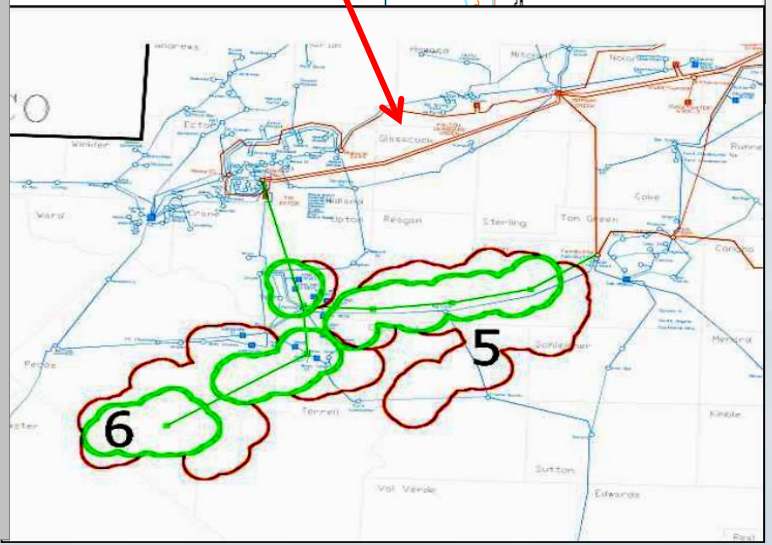


ISSUES: WIND ANALYSIS

Curtailment?





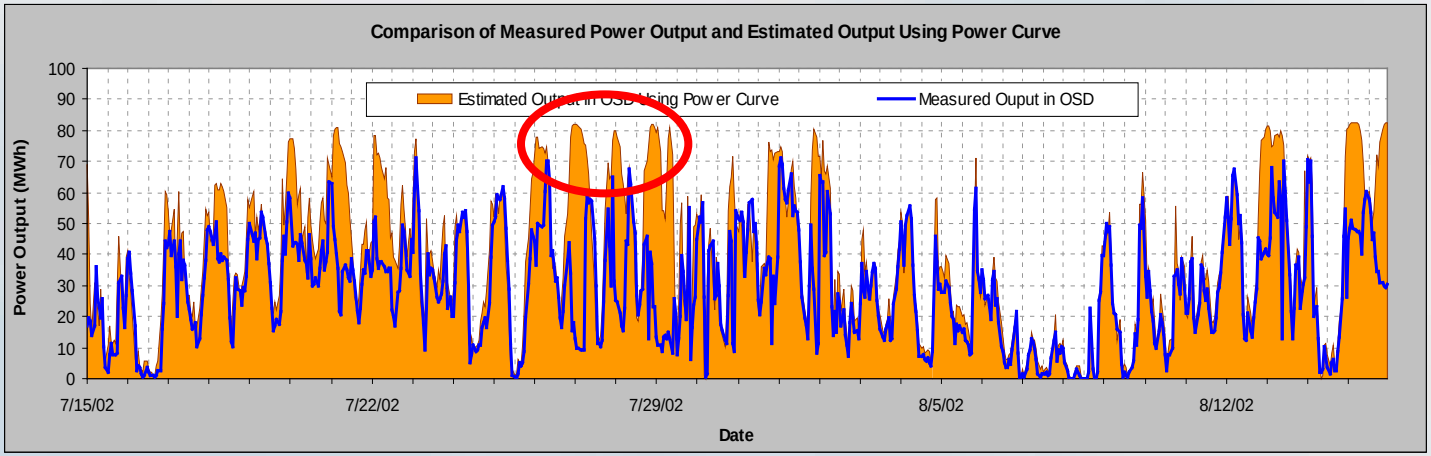


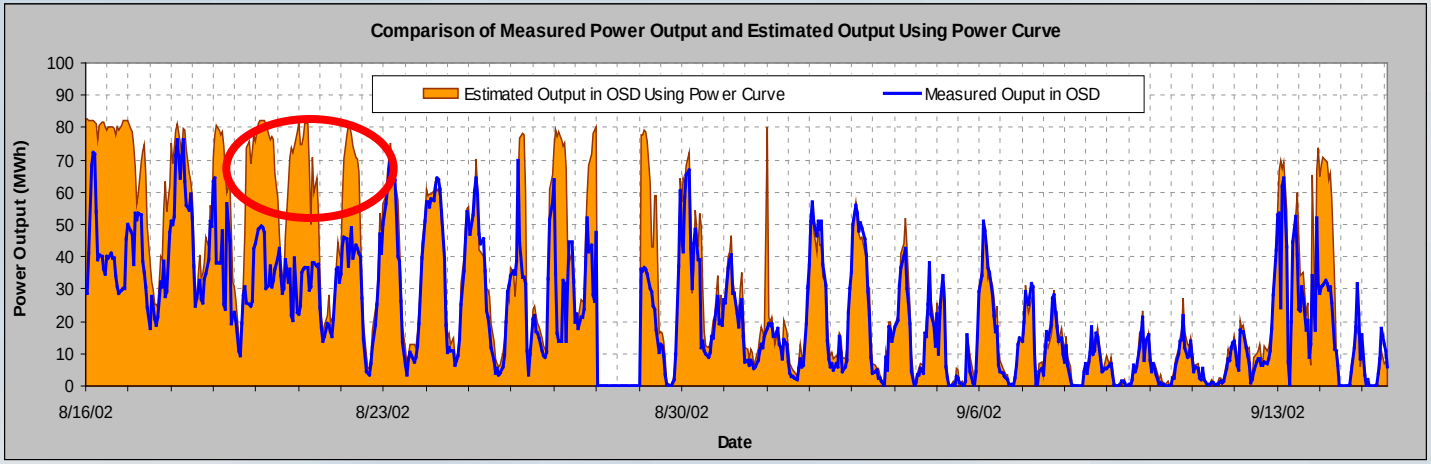
ISSUES: WIND ANALYSIS

Curtailment?

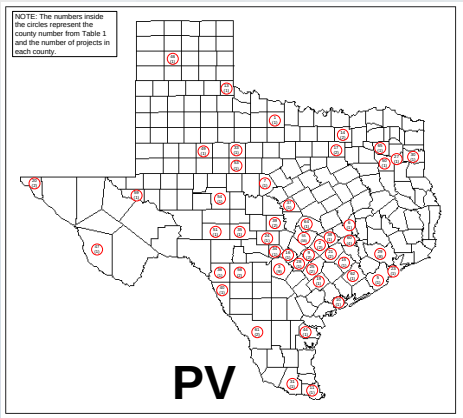
Predicted MWH in 2002 OSD Using Power Curve and On-site Wind	2002-2003 Measured in OSD	Curtailment and Maintenance Factor for OSD Period
52,565	38,678	26.4%

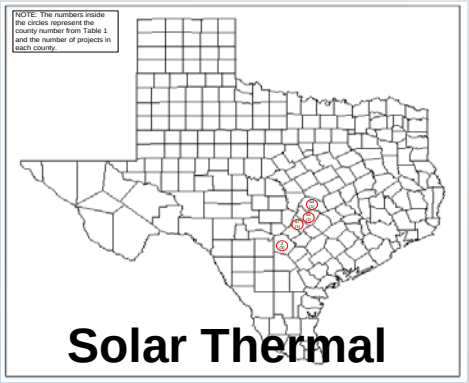
Predicted MWH Using Power Curve and On-site Wind (Jul 02 - Jan 03)	2002-2003 Measured (Jul 02 - Jan 03)	Curtailment and Maintenance Factor for Jul 02 - Jan 03
135,251	89,747	33.6%



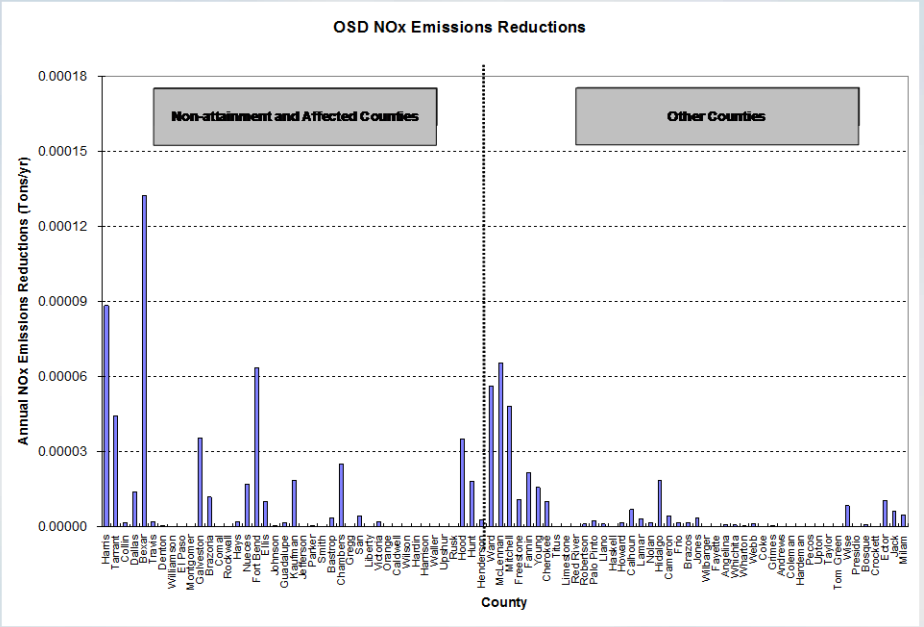


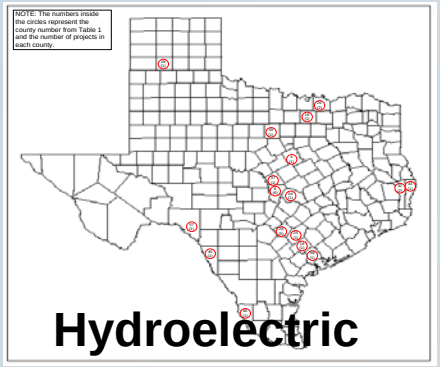
NOx SAVINGS FROM OTHER RENEWABLES

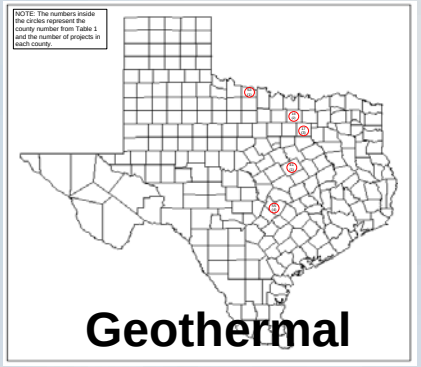


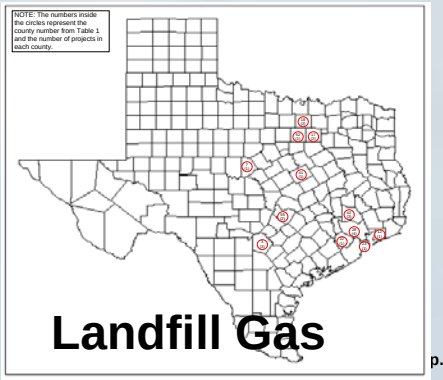


Other renewable energy sites quantified:



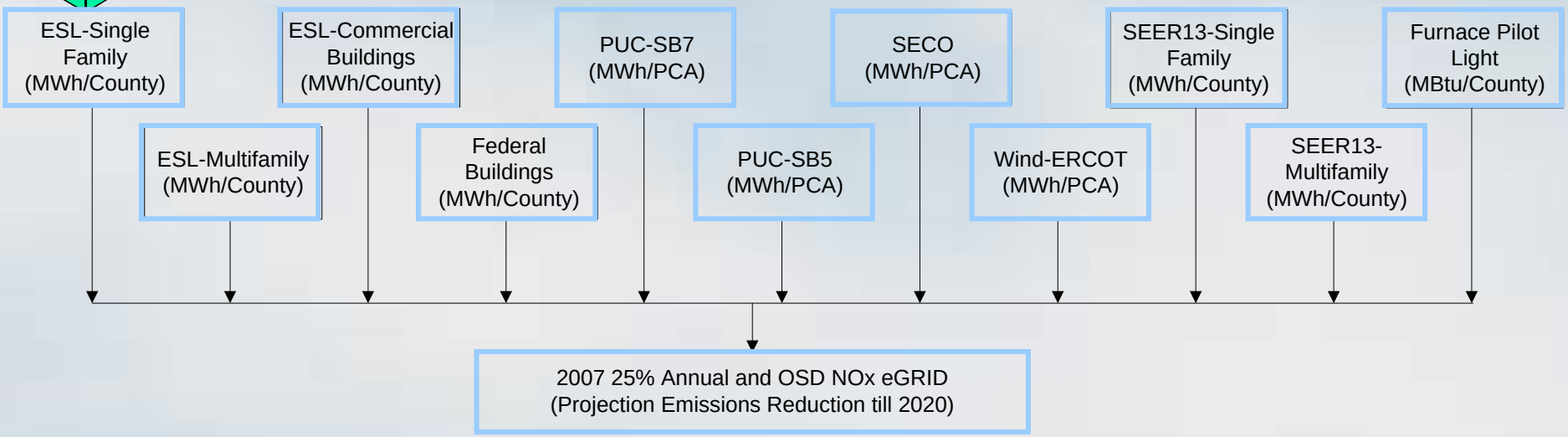






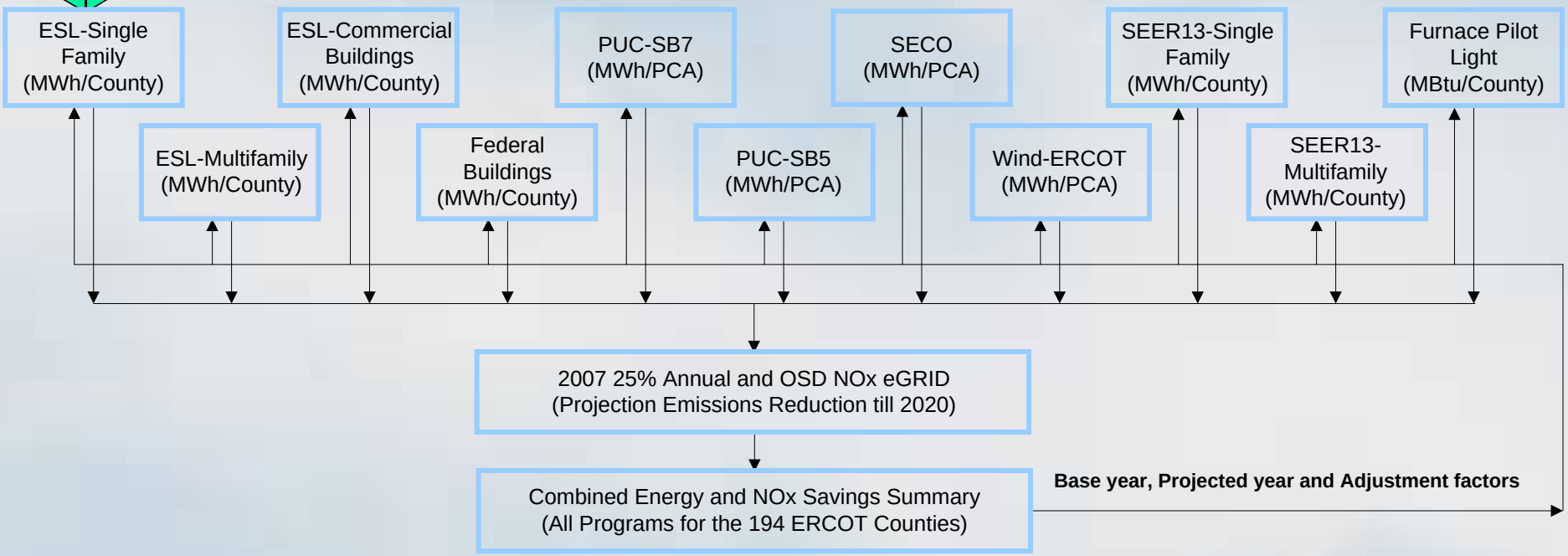
INTEGRATED NOx SAVINGS:

Process Flow Diagram of the NOx Emissions Reduction Calcs.



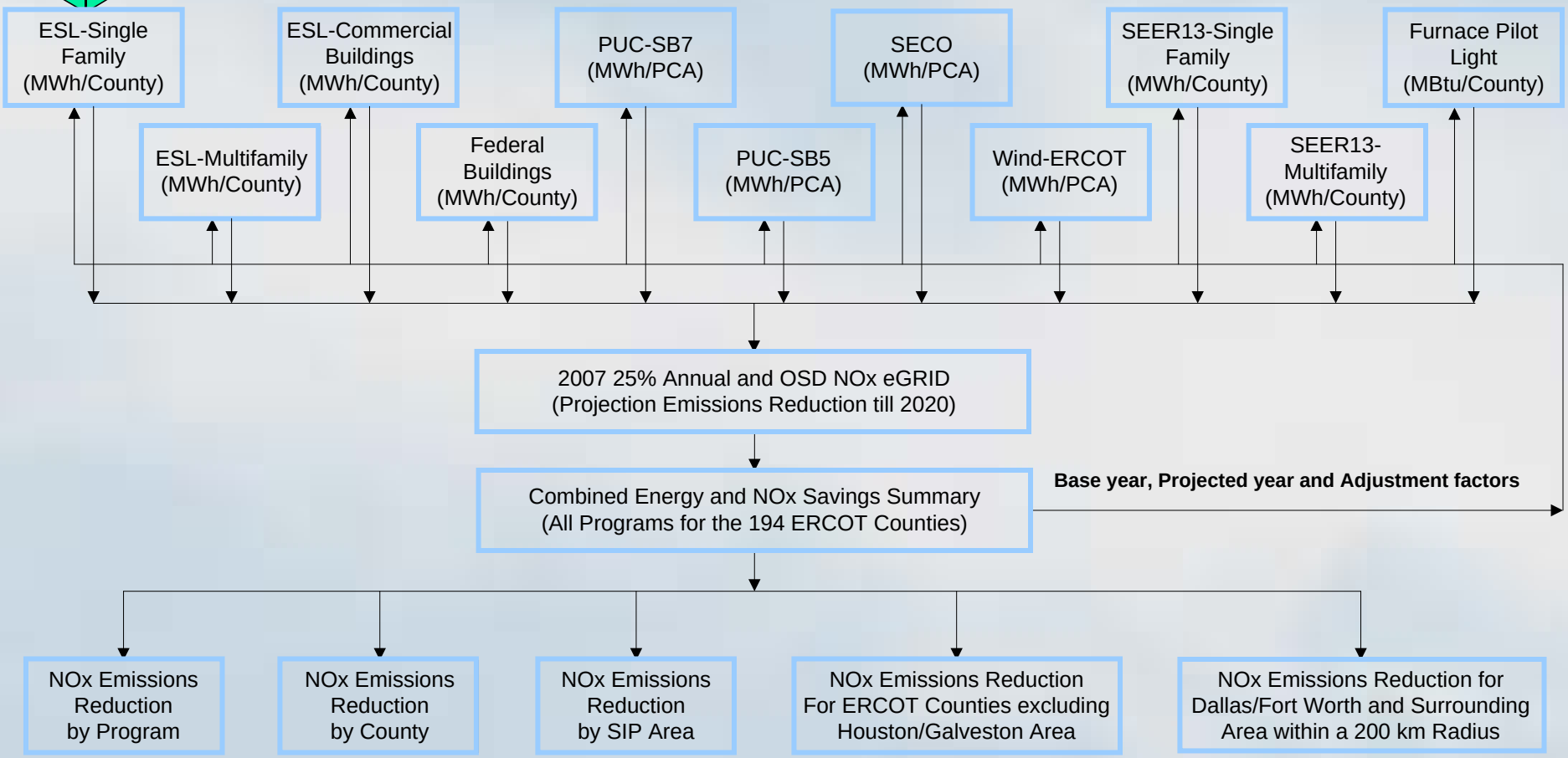
INTEGRATED NOx SAVINGS:

Process Flow Diagram of the NOx Emissions Reduction Calcs.



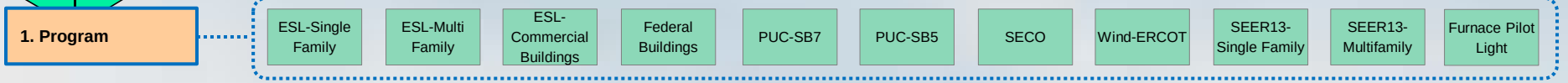
INTEGRATED NOx SAVINGS:

Process Flow Diagram of the NOx Emissions Reduction Calcs.



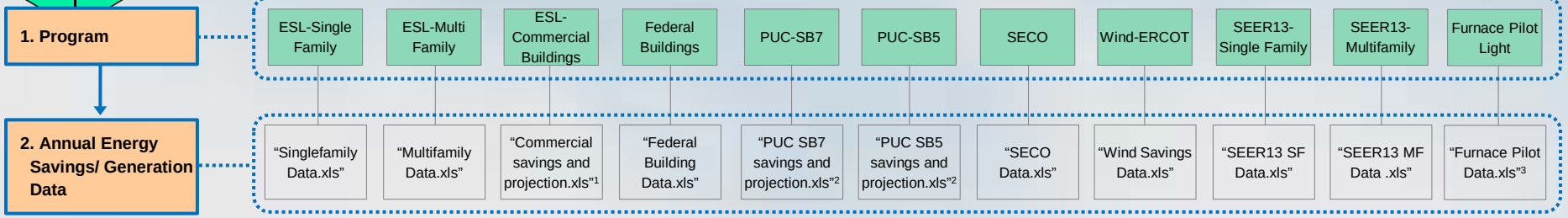
INTEGRATED NOx SAVINGS:

Process Flow Diagram of the NOx Emissions Reduction Calcs.



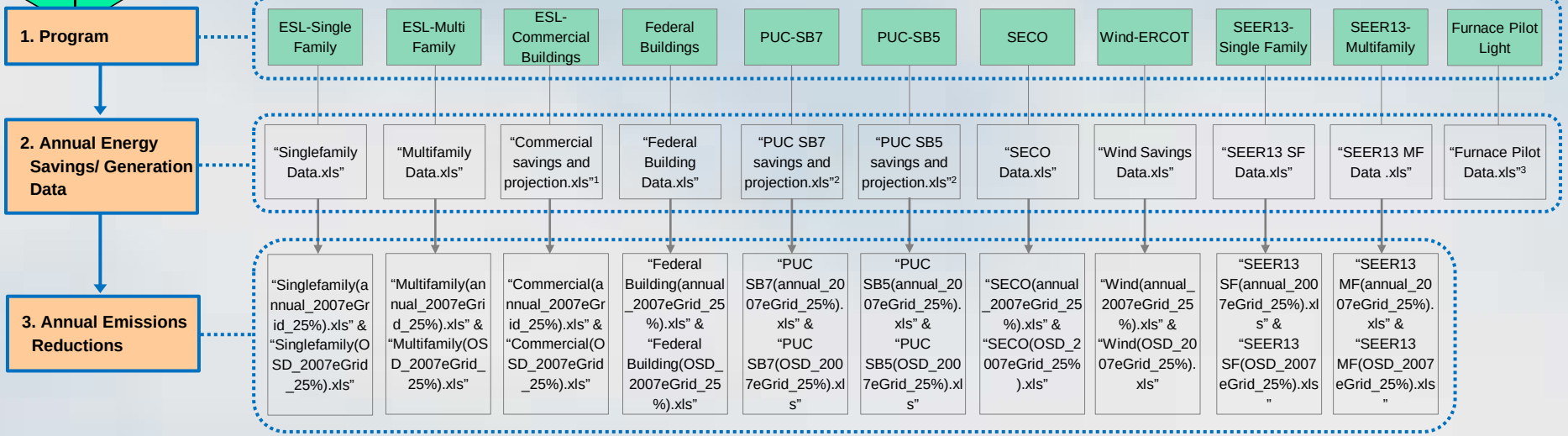
INTEGRATED NOx SAVINGS:

Process Flow Diagram of the NOx Emissions Reduction Calcs.



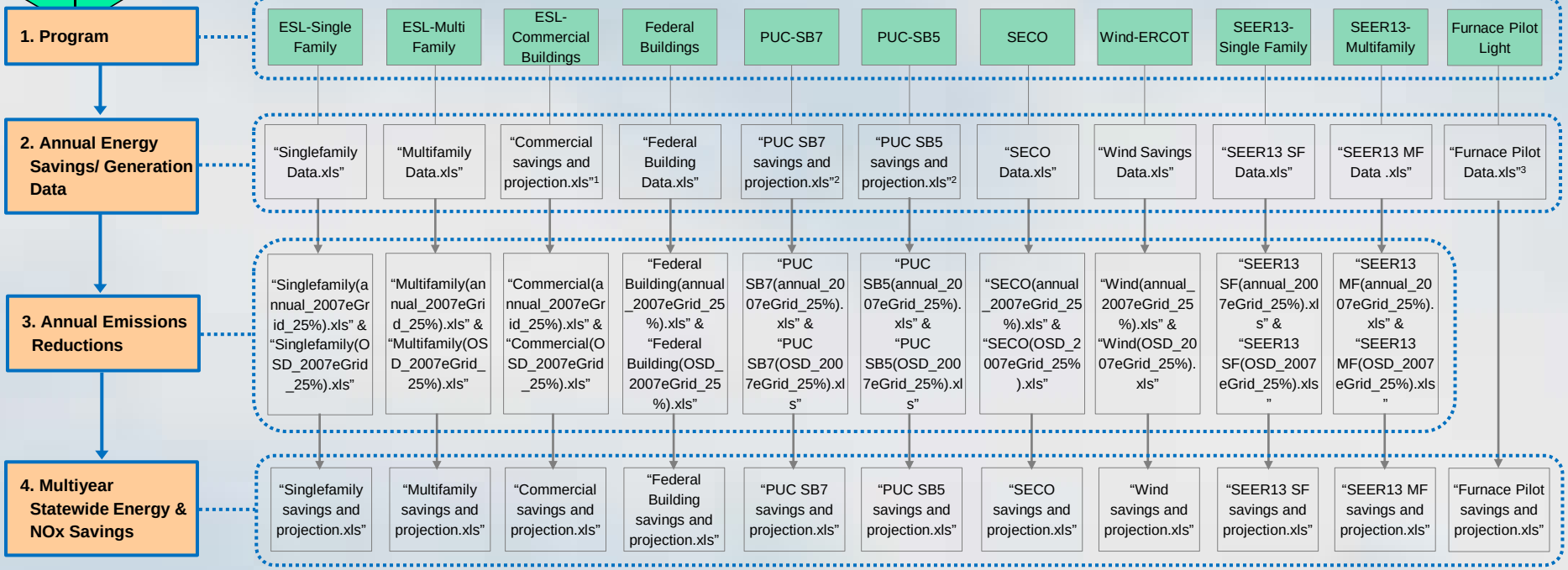
INTEGRATED NOx SAVINGS:

Process Flow Diagram of the NOx Emissions Reduction Calcs.



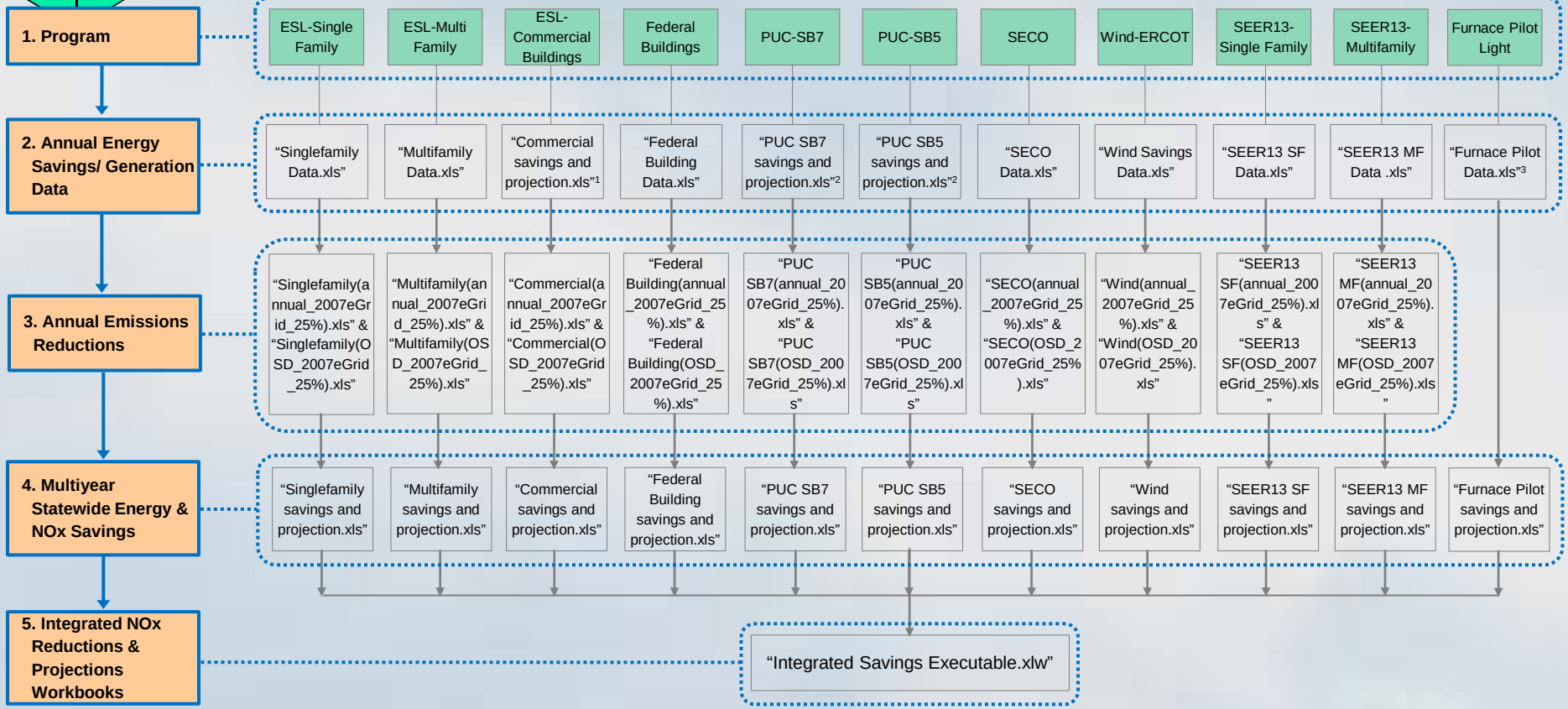
INTEGRATED NOx SAVINGS:

Process Flow Diagram of the NOx Emissions Reduction Calcs.



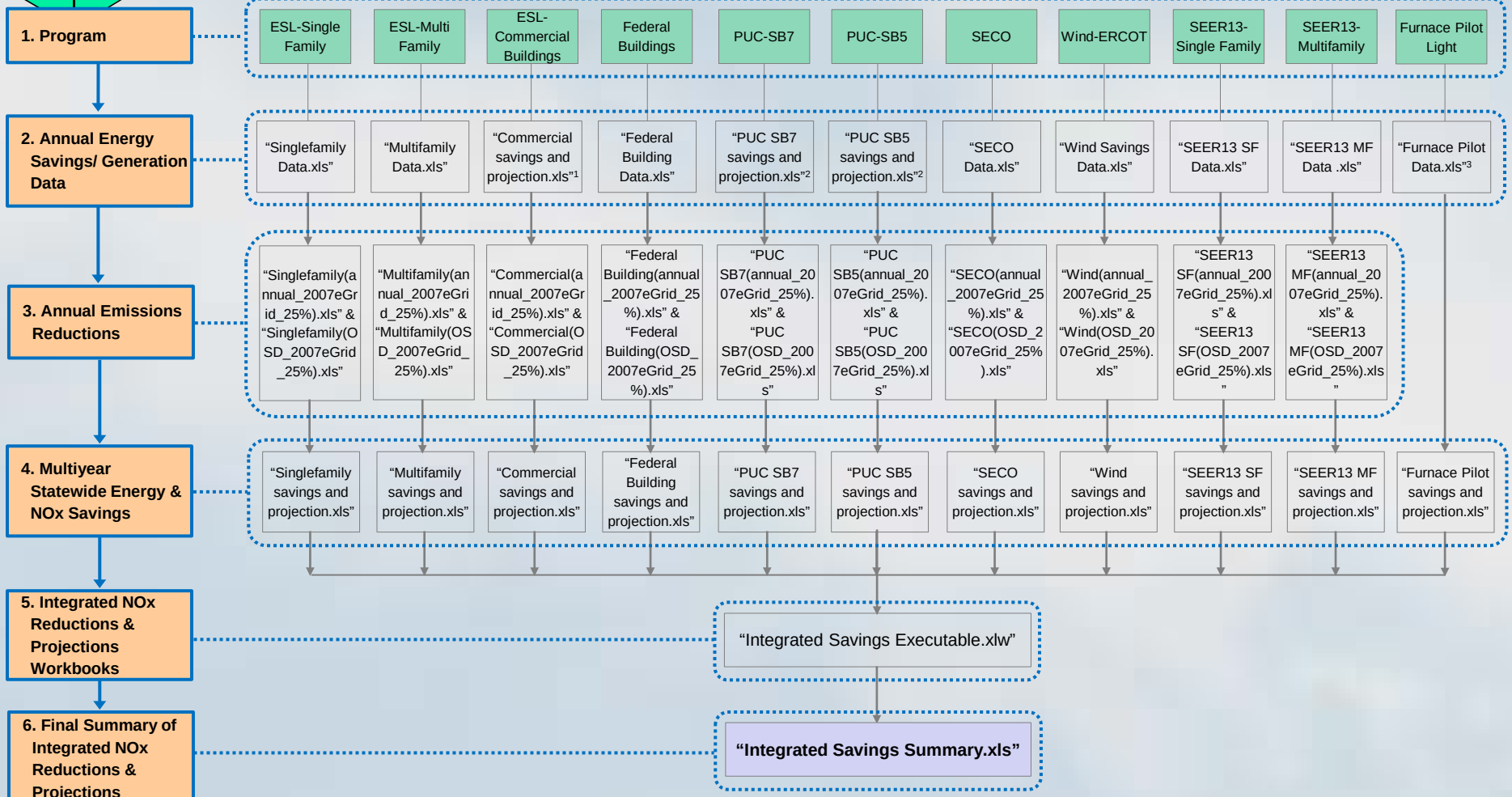
INTEGRATED NOx SAVINGS:

Process Flow Diagram of the NOx Emissions Reduction Calcs.

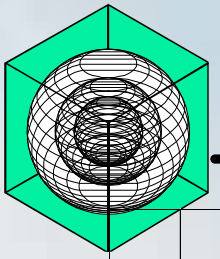


INTEGRATED NOx SAVINGS:

Process Flow Diagram of the NOx Emissions Reduction Calcs.



Note: 1. Energy savings data for commercial buildings are found in two excel files: Commercial Data.xls & Commercial savings and projection.xls.
2. Energy savings data for PUC SB5 and PUC SB7 are found in their savings and projection excel files.
3. The emissions factors contained in eGRID used for electricity savings only. Due to this, eGrid cannot be used for the emissions reduction in the furnace Pilot Light program achieved the N.G. savings by retrofitting existing furnaces.

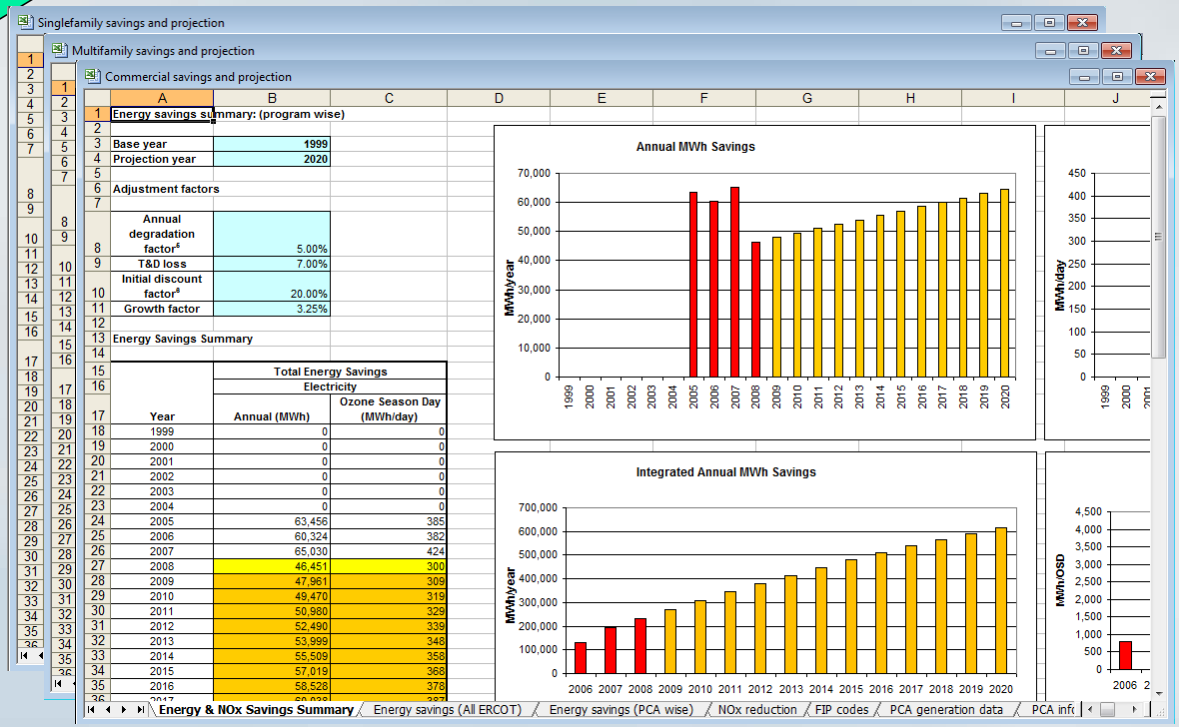


OSD 2007 eGrid for ERCOT EGUs

Area	County	American Electric Power - West (ERCOT) /PCA	NOx Reductions (lbs)	Austin Energy/PCA	NOx Reductions (lbs)	Brownsville Public Utils Board/PCA	NOx Reductions (lbs)	Lower Colorado River Auhotrity /PCA	NOx Reductions (lbs)	Reliant Energy HL&P/PCA	NOx Reductions (lbs)	San Antonio Public Service Bd/PCA	NOx Reductions (lbs)	South Texas Electric Coop INC/PCA	NOx Reductions (lbs)	Texas Municipal Power Pool/PCA	NOx Reductions (lbs)	Texas-New Mexico Power Co/PCA	NOx Reductions (lbs)	TXU Electric/PCA	NOx Reductions (lbs)	Total Nox Reductions (lbs)	Total Nox Reductions (Tons)
Houston-Galveston Area	Brazoria	0.00957217	5.424264354	0.011806715	0.313911143	0.007069474	0	0.004263638	0.475288866	0.071001767	118.4994141	0.016140391	9.71388065	0.006781035	0	0.005179719	0	0.126288049	4.762885928	0.008771659	33.56016258	172.7498077	0.086374904
	Chambers	0.021881395	12.3995373	0.027103415	0.720612302	0.016160386	0	0.009125896	1.017308902	0.165843463	276.7868179	0.037677498	22.67570398	0.01513807	0	0.009605529	0	0.011581666	0.435796301	0.015905217	60.85299339	374.8897701	0.187444885
	Fort Bend	0.055695513	31.5609937	0.068987309	1.834200727	0.041133619	0	0.023228475	2.589393382	0.422127404	704.5155639	0.095907935	57.71729485	0.038531479	0	0.025449302	0	0.024449102	0.84048129	0.024439129	154.8913394	954.2205795	0.47711029
	Galveston	0.027555985	15.61515886	0.033893644	0.901147567	0.020351324	0	0.012791501	1.425932152	0.201446635	336.2072396	0.045812515	27.57165538	0.019823685	0	0.01677514	0	0.594656509	22.42715078	0.028709453	109.8416998	513.9899851	0.256994993
	Harris	0.077360573	43.83794041	0.09582276	2.547688546	0.057134232	0	0.032264145	3.596644449	0.586331222	978.5658716	0.13320669	80.16881079	0.053519883	0	0.033959864	0	0.040946397	1.544271352	0.056232096	215.1426971	1325.403924	0.662701962
	Liberty	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Montgomery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Waller	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beaumont/ Port Arthur Area	Hardin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Jefferson	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Orange	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dallas/ Fort Worth Area	Collin	0.001763649	0.999407477	0.003151138	0.083780901	0.001302533	0	0.005050143	0.562964483	0.002085751	3.48104438	0.00060408	0.363557551	0.015958397	0	0.063788818	0	0.000846136	0.031911564	0.004013208	15.35443911	20.87710546	0.010438553
	Dallas	0.005045553	2.859165058	0.005305276	0.141054072	0.003726366	0	0.008757286	0.976218186	0.002413087	4.027355603	0.000782263	0.47079481	0.009310387	0	0.033672029	0	0.008209179	0.309604793	0.044002183	168.351334	177.1355265	0.088567763
	Denton	0.000635758	0.360265084	0.001170951	0.031132659	0.000469535	0	0.001874207	0.208927158	0.000785431	1.310856012	0.000226691	0.13643089	0.006095882	0	0.024399888	0	0.00025035	0.009441813	0.001139562	4.359938949	6.416992564	0.003208496
	Tarrant	0.015572243	8.824328016	0.015705165	0.417561234	0.011500796	0	0.026002176	2.898591708	0.006806985	11.3606147	0.002243821	1.350413759	0.022183886	0	0.077098512	0	0.026379614	0.994892954	0.141667156	542.015255	567.8616574	0.283930829
	Ellis	0.003502824	1.98494617	0.003532723	0.09392631	0.002586991	0	0.005848935	0.652009819	0.001531165	2.555459021	0.000504725	0.30376235	0.004990048	0	0.017342555	0	0.005933836	0.223791427	0.031866639	121.9210236	127.7349187	0.063867459
	Johnson	0.000337176	0.191067649	0.000621017	0.016511297	0.00024902	0	0.000993991	0.110805134	0.000416556	0.695216349	0.000120226	0.072356524	0.003232969	0	0.012940552	0	0.000132774	0.005007494	0.00060437	2.312306471	3.403270919	0.001701635
	Kaufman	0.006492753	3.679250135	0.006548174	0.174099628	0.004795187	0	0.01084145	1.208550262	0.002838131	4.736739508	0.000935547	0.56304684	0.009249437	0	0.032145758	0	0.01099882	0.414814593	0.059067263	225.9899787	236.7664796	0.11838324
	Parker	0.000475952	0.269707644	0.000876616	0.023307049	0.000351511	0	0.0014031	0.156410527	0.000588002	0.981354847	0.000169709	0.102137163	0.0045636	0	0.012866655	0	0.000187421	0.007068487	0.000853118	3.264010067	4.803995784	0.002401998
	Rockwall	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Henderson	0.000950271	0.538490397	0.000958382	0.025481001	0.000701818	0	0.001586741	0.176881888	0.000415385	0.693263205	0.000136926	0.082406824	0.001353736	0	0.004704812	0	0.001609773	0.060711739	0.00864501	33.0756075	34.65284255	0.017326421
	Hood	0.012327882	6.985844785	0.012433111	0.330565451	0.00910469	0	0.020584816	2.294691645	0.0053888	8.993714963	0.001776337	1.069065078	0.017562038	0	0.061035609	0	0.020883617	0.787614393	0.112151856	429.0904005	449.5518968	0.224775948
	Hunt	0.006351211	3.599042893	0.006405424	0.170304276	0.004690653	0	0.010605108	1.18220401	0.00277626	4.633479116	0.000915153	0.550772482	0.0090478	0	0.031444984	0	0.010759047	0.405771681	0.057779603	221.0634224	231.6049968	0.115802498
El Paso Area	El Paso	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
San Antonio Area	Bexar	0.031128114	17.63937809	0.048234164	1.282426288	0.0229895	0	0.084461674	9.415362189	0.001063735	1.775335135	1.065346769	641.164862	0.043667482	0	0.004350128	0	0.00048404	0.018255338	0.002332591	8.924437434	680.2200565	0.340110028
	Comal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Guadalupe	0.002007611	1.137653332	0.076651484	2.03797205	0.00148271	0	0.134326688	14.97406286	0.00124155	2.072103313	0.00356749	2.147046682	0.001065557	0	0.001862326	0	0.00040353	0.015204692	0.001841718	7.046370275	29.43041321	0.014715207
	Wilson	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Austin Area	Bastrop	0.004469515	2.532741249	0.170648096	4.53710786	0.003300936	0	0.299049574	33.33654075	0.002764046	4.613093798	0.007942252	4.779391443	0.002372235	0	0.004146069	0	0.000897533	0.033849987	0.00410019	15.68732278	65.52050557	0.032760253
	Caldwell	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hays	0.002469353	1.399308965	0.094281013	2.50669721	0.001823727	0	0.165221279	18.41803633	0.001527102	2.548678635	0.004387998	2.640858674	0.001310631	0	0.002290653	0	0.000495876	0.018701709	0.002265306	8.667006739	36.19928838	0.018099644
	Travis	0.000507609	0.28764703	0.298194277	7.92824316	0.000374892	0	0.033779905	3.765613682	0.000333135	0.555990587	0	0	0.000269863	0	0.000469526	0	0.000102841	0.003878595	0.000465139	1.779609198	14.32098225	0.007160491
	Williamson	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North East Texas Area	Gregg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Harrison	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Rusk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Smith	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Upshur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Corpus Christi Area	Nueces	0.223524525	126.6647136	0.00447587	0.119002233	0.165082827	0	0.007477478	0.83355159	0.001651016	2.755487088	0.001597886	0.961666323	0.045960479	0	0.007117588	0	0.001580824	0.059619939	0.008136188	31.1288651	162.5229059	0.081261453
	San Patricio	0.055330886	31.35437077	0.001107949	0.029457613	0.040864326	0	0.001850962	0.206335963	0.00040869	0.682088653	0.000395538	0.238049269	0.01137698	0	0.001761876	0	0.000391315	0.01475822	0.002014018	7.705587061	40.23064755	0.020115324
Victoria Area	Victoria	0.020604752	11.67610137	0.002090584	0.055583411	0.015217528	0	0.003408874	0.380004159	0.001131941	1.889169055	0.000524055	0.315395512	0.495811308	0	0.030584062	0	0.000449952	0.016969703	0.002127635	8.140283057	22.47350627	0.011236753
	Andrews	2.56527E-05	0.014536603	2.58716E-05	0.000687862	1.89456E-05	0	4.28342E-05	0.004774944	1.12134E-05	0.01871471	3.69632E-06	0.002224581	3.65442E-05	0	0.000127007	0	4.3456E-05	0.00163892	0.000233373	0.89287937	0.93545699	0.000467728
	Angelina	0.00032149	0.182178934	0.000324234	0.008620584	0.000237435	0	0.000536817	0.05984165	0.000140531	0.234540768	4.63239E-05	0.027879396	0.000457988	0	0.000544609	0.02053964	0.002924729	0.011894683	11.7235478	0.005861774	
	Bosque	0.000939453	0.53235995	0.001730301	0.046004405	0.000693828	0	0.002769496	0.308734478	0.001160623	1.937038231	0.000334975	0.2016025	0.009007821	0	0.003699039	0.013952069	0.001683919	6.442636225	9.482322857	0.004741161		
	Brazos	0.001913926	1.08456525	0.003525105	0.093723765	0.00141352	0	0.005642234	0.628967795	0.002364512	3.946285505	0.000682445	0.410720352	0.018351436	0	0.073454996	0	0.00075367	0.028424244	0.003430612	13.12544148	19.31812839	0.009659064	
	Calhoun	0.088525246	50.16462921	0.001772635	0.04712996	0.065379841	0	0.0029614	0.330121983	0.000653873	1.091290417	0.000632831	0.380860882	0.01820231	0	0.002818869	0	0.000626074	0.023612039	0.003222277	12.32835832	64.36600281	0.032183001	
	Cameron	0.054672288	30.9811625	0.001094762	0.029106982	0.285623104	0	0.001828931	0.203879964	0.000403825	0.673969812	0.00039083	0.23521579	0.011241561	0	0.001740904	0	0.000386657	0.014582554	0.001990046	7.613868149	39.75178576	0.019875893	
	Cherokee	0.003512995	1.990710067	0.003542982	0.094199054	0.002594504	0	0.005865919	0.653903128	0.001535611	2.562879576	0.000506191	0.304644417	0.005004538	0	0.017392915	0	0.005951066	0.224441274	0.031959174	122.2750585	128.1035836	0.064052918	
	Coke	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Coleman	0.001355099	0.767894576	2.71346E-05	0.000721441	0.001000801	0	4.53316E-05	0.005053339	1.00092E-05	0.016704917	9.68705E-06	0.005830024	0.000278632	0	4.31498E-05	0	9.58362E-06	0.000361441	4.9325E-05	0.188716226	0.985281965	0.000492641
	Crockett	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ector	0.003629264	2.056595939	0.003660242	0.097316729	0.002680373	0	0.006060061	0.675545143	0.001586434	2.647702352	0.000522944	0.314727133	0.005170172	0	0.017968562	0	0.006148027	0.231869532	0.033016916	126.3219556	132.3457125	0.066172856	
	Fannin	0.007628516	4.322853681	0.007693632	0.204554513	0.005633999	0	0.012737922	1.419959436	0.003334599	5.565327463	0.001099201	0.661539448	0.010867422	0	0.037768948	0	0.00162872	0.487377244	0.069399776	265.5219339	278.1835457	0.139091773	
	Fayette	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Freestone	0.003774434	2.138859776	0.003806652	0.101209398	0.002787588	0	0.006302464	0.702566949	0.001649892	2.753610446	0.000543862	0.327316218	0.005376978	0	0.018687305	0	0.006393948	0.241144314	0.034337593	131.3748339	137.639541	0.06881977	
	Frio	0.014763838	8.366228886	0.001497957	0.039826953	0.010903753	0	0.002442547	0.272282817	0.000811065	1.353638532	0.000375499	0.225989049	0.355261637	0	0.021914272	0	0.000322402	0.012159232	0.001524506	5.832723532	16.102849	0.008051424	
	Grimes	0.000554424	0.314175749	0.001021149	0.027149804	0.000409467	0	0.001634436	0.182198746	0.000684949	1.143155937	0.00019769	0.11897705	0.005316025	0	0.012178368	0	0.000218322	0.008233906	0.000993776	3.802164425	5.596055616	0.002798028	
	Hardeman	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Haskell	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hidalgo	0.239736996	135.8518392	0.004800509	0.127633591	0.177056459	0	0.008019827	0.894009968	0.001770766	2.955345481	0.001713782	1.031416998	0.049294041	0	0.001695483	0.063944236	0.008726314	0.307633834	0.038667461	14.73108641	0.087155432	
	Howard	0.000585081	0.331547959	0.000590075	0.015688625	0.00043208	0	0.000976955	0.108905989	0.000255752	0.426841411	8.43049E-05	0.050737793	0.000833494	0	0.002896748	0	0.000991136	0.037380153	0.005322723	20.36461603	21.33571796	0.010667859	
	Jack	0.002177558	1.233957563	0.002196145	0.058390037	0.001608224	0	0.003636037	0.405327086	0.000951861	1.588621411	0.000313767	0.18883628	0.003102103	0	0.010781137	0	0.003688816	0.139121719	0.01981015	75.79317399	79.40742748	0.039703714	
	Jones	0.042500124	24.08355856	0.000851025	0.022626643	0.031388236	0	0.00142174	0.158488406	0.000313918	0.523918089	0.000303816	0.182847666	0.008738755	0	0.001353312	0	0.000300577	0.011335914	0.001546985	5.918726884	30.90150216	0.015450751	
Other ERCOT counties	Lamar	0.00107998	0.611992877	0.001089195	0.028959698	0.000797614	0	0.001803327	0.201025785	0.000472301	0.787891747	0.000159516	0.093655131	0.001538517	0	0.001829503	0.068998727	0.00082503	0.31559851	37.5903361	39.38286135	0.019691431	
	Limestone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Llano	0.00124346	0.704631819	0.047475864	1.262264973	0.000918351	0	0.083198331	9.274531047	0.000768983	1.283404957	0.002209607	1.32982286	0.000659977	0	0.001153474	0	0.000249702	0.009417376	0.00114071	4.364331877	18.22840491	0.009114202	
	McLennan	0.023031368	13.05119284	0.023227961	0.617573619	0.017009692	0	0.038457253	4.287020982	0.01006754	16.80236421	0.003318614	1.997263741	0.032805992	0	0.114028801	0	0.039015483	1.471448	0.209525912	801.6412813	839.8681447	0.419934072	
	Milam	0.001652492	0.936418221	0.001666598	0.044310677	0.001220439	0	0.002759294	0.307592157	0.000722342	1.205563368	0.000238109	0.143302929	0.002354105	0	0.008181524	0	0.002799346	0.105575845	0.015033406	57.51746309	60.26022629	0.030130113	
	Mitchell	0.016961453	9.611551951	0.017106233	0.454812138	0.012526789	0	0.028321847	3.157176925	0.00741424	12.37410238	0.002443993	1.470885033	0.024162925	0	0.083976519	0	0.028732956	1.08364799	0.154305373	590.3687819	618.5299583	0.309260479	
	Nolan	0.000603273	0.34185684	0.000608422	0.016176434	0.000445544	0	0.001007331	0.112292222	0.000263704	0.440113268	8.69262E-05	0.052153592	0.00085941	0	0.002986817	0	0.001021953	0.038542421	0.005488224	20.99781673	21.99911331	0.010999557	
	Palo Pinto	0.003074879	1.742442836	0.00566337	0.150574899	0.002270935	0	0.00906471	1.010488239	0.003798781	6.340030632	0.001096403	0.659855859	0.029483083	0	0.118011463	0	0.001210832	0.045665874	0.005511559	21.08709584	31.03615428	0.015518077	
	Pecos	4.22618E-05	0.023948497	4.26225E-05	0.001133227	3.12122E-05	0	7.05678E-05	0.007866538	1.84736E-05	0.03083177	6.08954E-06	0.003664911	6.02052E-05	0	0.002092339	0	7.15921E-05	0.002700057	0.000384473	1.47098462	1.541129621	0.000770565	
	Presidio	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Red River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Robertson	0.000359257	0.203580551	0.000406685	0.01081274	0.000265328	0	0.00035838 5	0.039951004	0.001533867	2.559968743	0.00035593	0.214211849	0.000370532	0	0.000908875	0	0.09332343	3.519643031	0.00165467	6.330727693	12.87889561	0.006439448
	Taylor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Titus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tom Green	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Upton	3.2238E-05	0.018268289	3.25131E-05	0.000864443	2.38092E-05	0	5.38302E-05	0.006000719	1.40919E-05	0.023518958	4.6452E-06	0.002795652	4.59255E-05	0	0.000159611	0	5.46116E-05	0.002059646	0.000293282	1.122090155	1.175597862	0.000587799	
	Ward	0.019807626	11.22439351	0.0199767	0.53113071	0.014628815	0	0.033074321	3.686958815	0.008658368	14.45050656	0.002854101	1.717703083	0.028217522	0	0.098067981	0	0.033554415	1.265486732	0.180198187	689.434085	722.3102644	0.361155132	
	Webb	0.014180046	8.035410948	0.00028342	0.007549315	0.010472596	0	0.000474359	0.052879207	0.000104738	0.174803783	0.000101367	0.061006605	0.002915661	0	0.000100285	0.003782195	0.000516147	0.194766424	0.031019848	0.005155099		
	Wharton	0.00015439	0.087488222	0.000191235	0.005084471	0.000114024	0	6.43902E-05	0.007177893	0.001170153	1.95294276	0.000265844	0.15999444	0.000106811	0	6.77744E-05	0.003081932	0.000112223	0.429364425	2.645134142	0.001322567		
	Wichita	0.000219843	0.124578471	0.000221719	0.005894969	0.000162364	0	0.000367089	0.040921203	9.60984E-05	0.160384791	3.16774E-05	0.019064622	0.000313184	0	0.001088447	0	0.000372417	0.014045516	0.002000002	7.651963014	8.016852587	0.004008426	
	Wilbarger	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Wise	0.002918471	1.653810839	0.002955932	0.078590865	0.002155421	0	0.004892446	0.545385256	0.001287753	2.149213907	0.000423725	0.25501353	0.004280539	0	0.014952843	0	0.004924352	0.185719287	0.026440527	101.1608443	106.028578	0.053014289	
	Young	0.00549666	3.114794166	0.005543579	0.147389953	0.004059529	0	0.009178198	1.023139272	0.002402716	4.010047113	0.000792019	0.476666426	0.007803145	0	0.027214083	0	0.009311425	0.351175383	0.050005398	191.3149421	200.4042105	0.100221353	
	Total		**1.143037355**	**647.7253396**	**1.154658244**	**30.69948697**	**1.089429227**	**0**	**1.180868675**	**131.6372942**	**1.539350626**	**2569.121226**	**1.443063194**	**868.4884961**	**1.48172714**	**0**	**1.269705424**	**0**	**1.151968562**	**43.44587545**	**1.517782624**	**5807.001134**	**10098.11885**	**5.049059426**
	Energy Savings by PCA (MWh)	566.67		26.59		0		111.47		1668.96		601.84		0		0		37.71		3825.98			

INTEGRATED NOx SAVINGS:

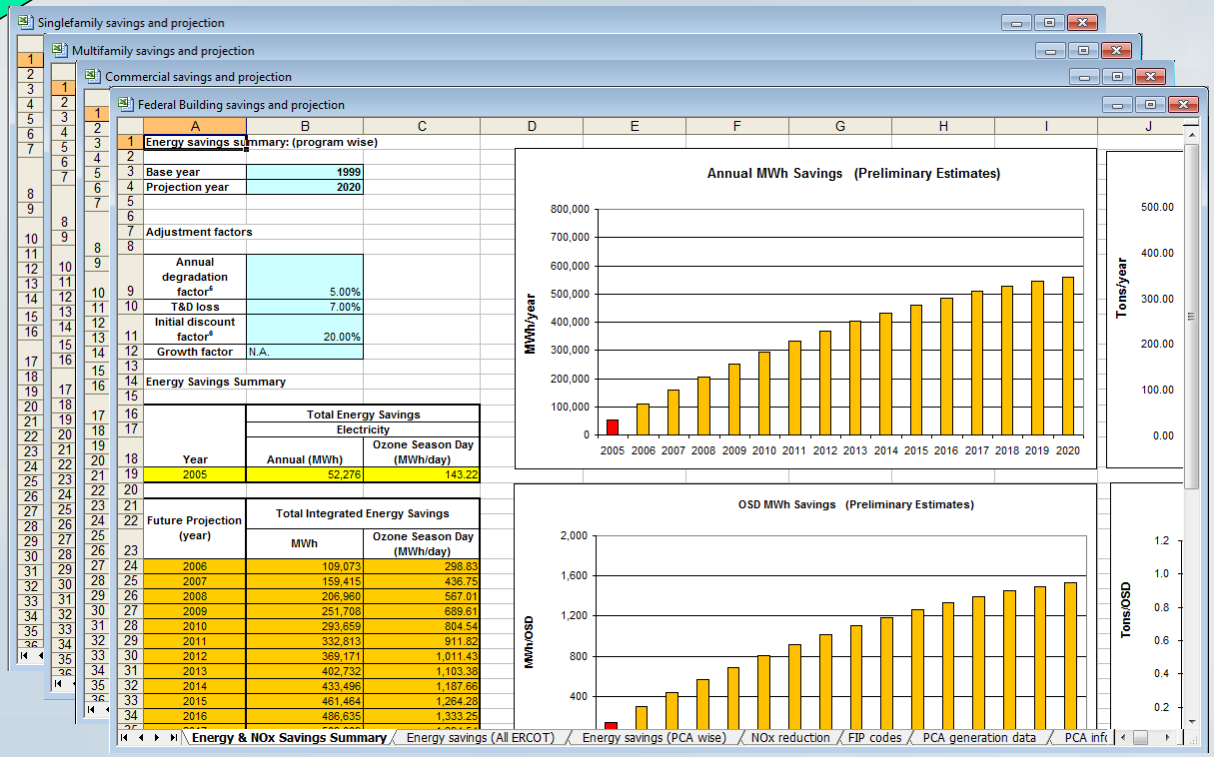
Final Summary Tables For Integrated NOx Reductions & Projections



ESL-Single Family / ESL-Multi Family / ESL-Commercial Buildings

INTEGRATED NOx SAVINGS:

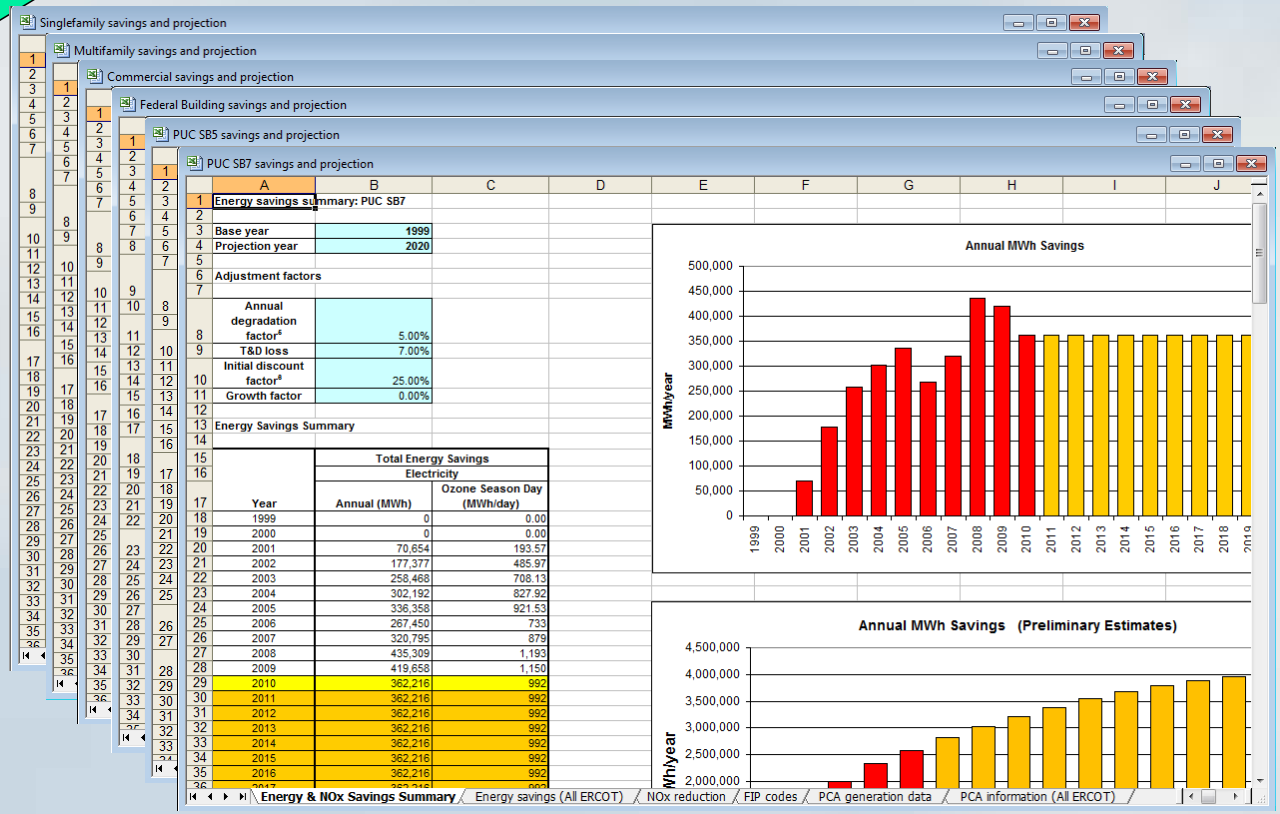
Final Summary Tables For Integrated NOx Reductions & Projections



Federal Buildings

INTEGRATED NOx SAVINGS:

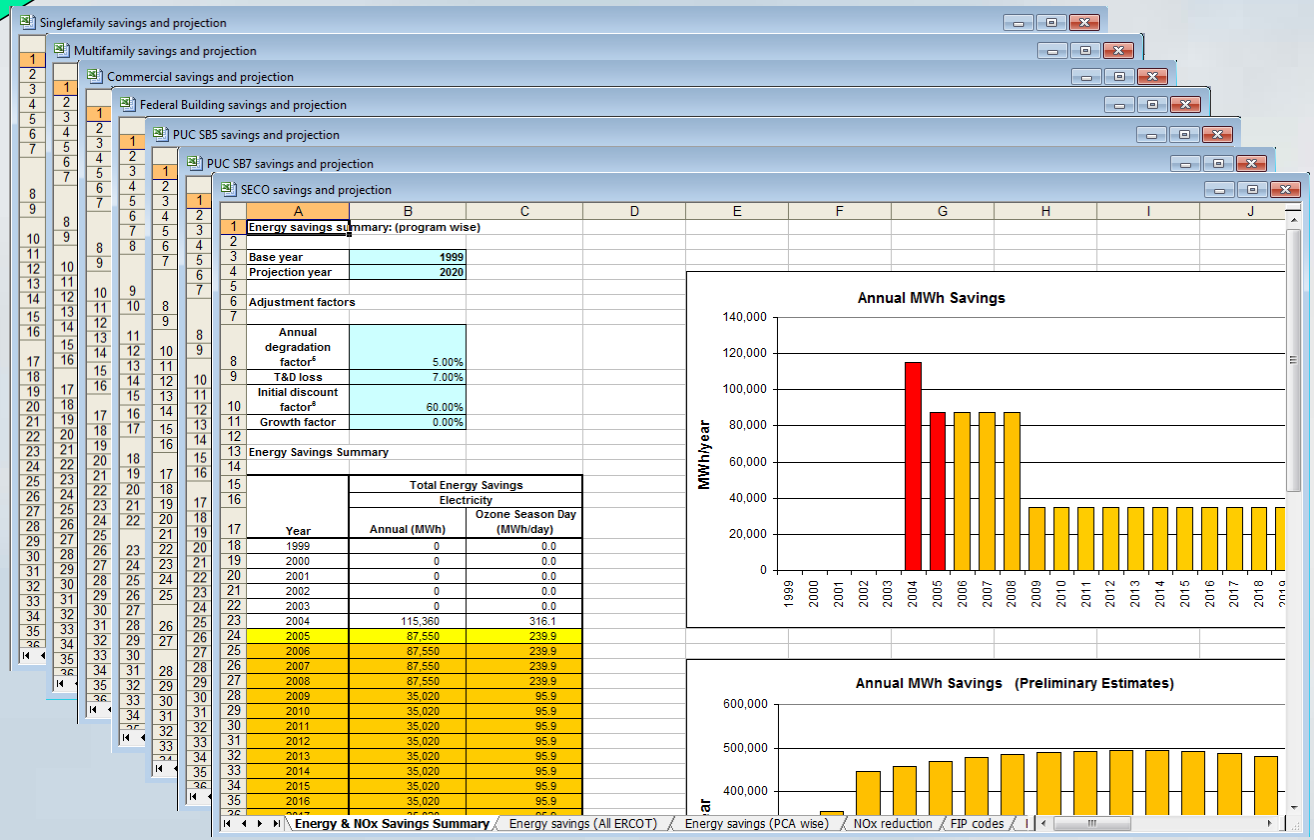
Final Summary Tables For Integrated NOx Reductions & Projections



PUC SB5 / PUC SB7

INTEGRATED NOx SAVINGS:

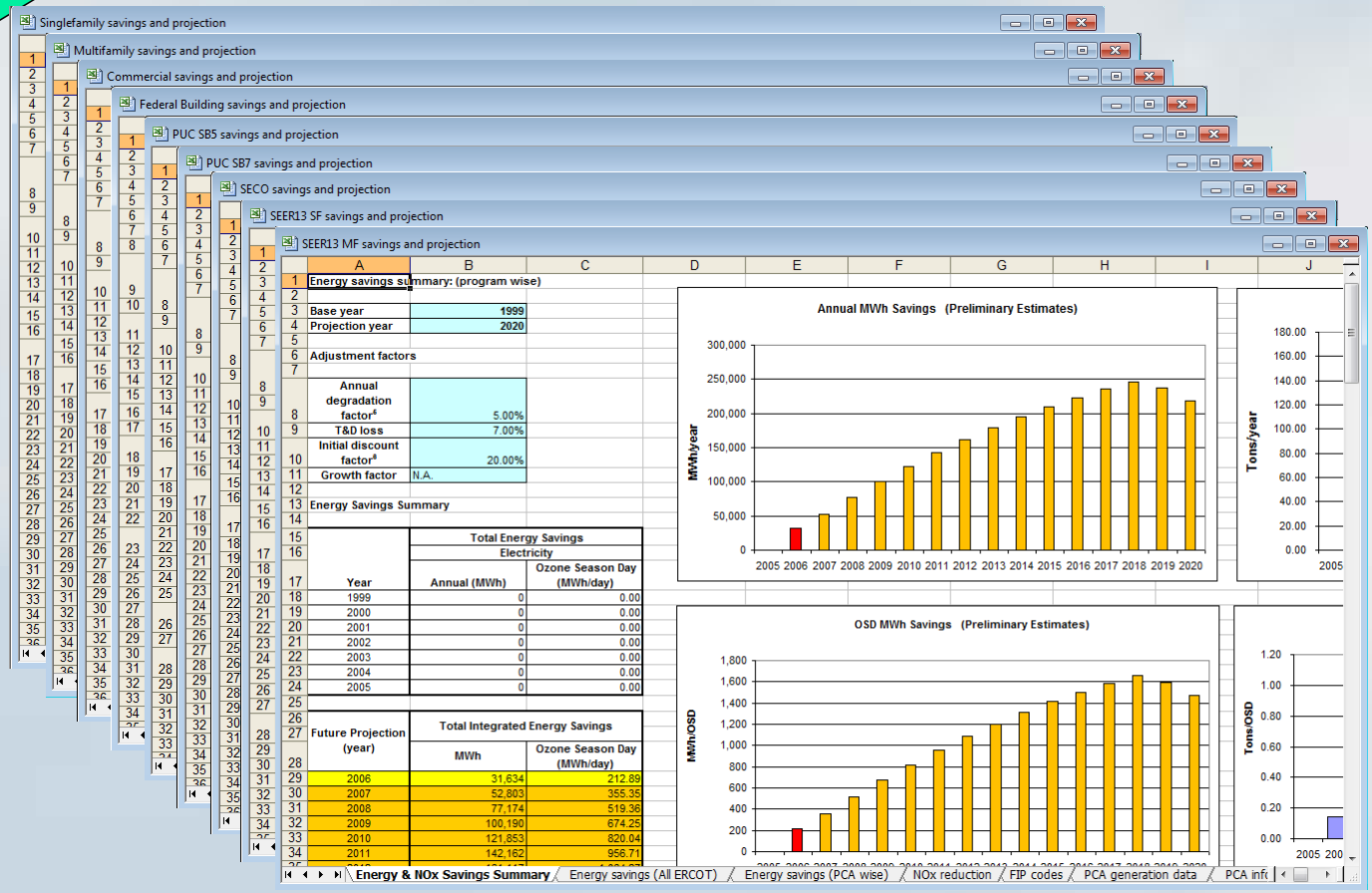
Final Summary Tables For Integrated NOx Reductions & Projections



SECO

INTEGRATED NOx SAVINGS:

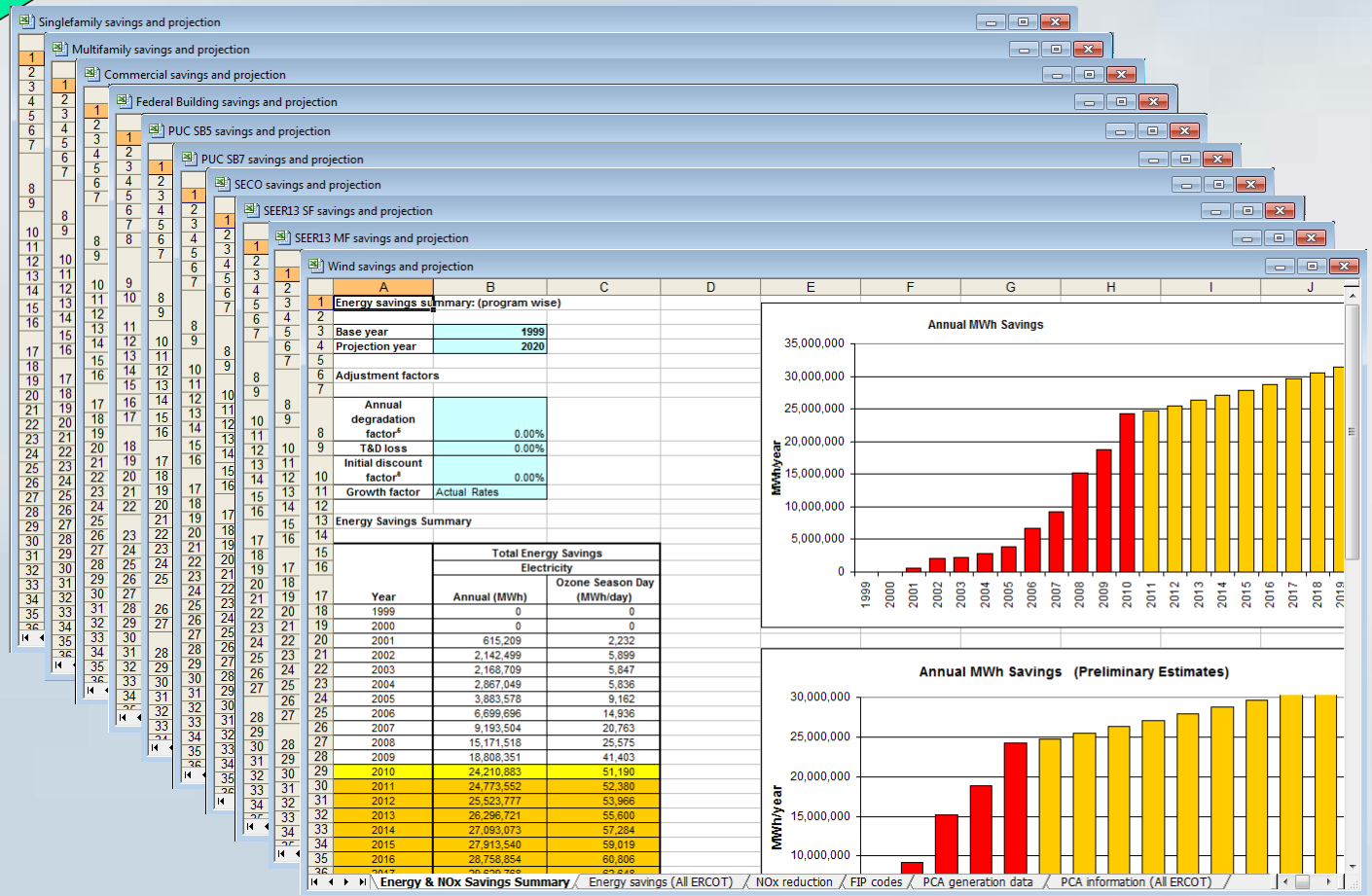
Final Summary Tables For Integrated NOx Reductions & Projections



SEER13 MF / SEER13 SF

INTEGRATED NOx SAVINGS:

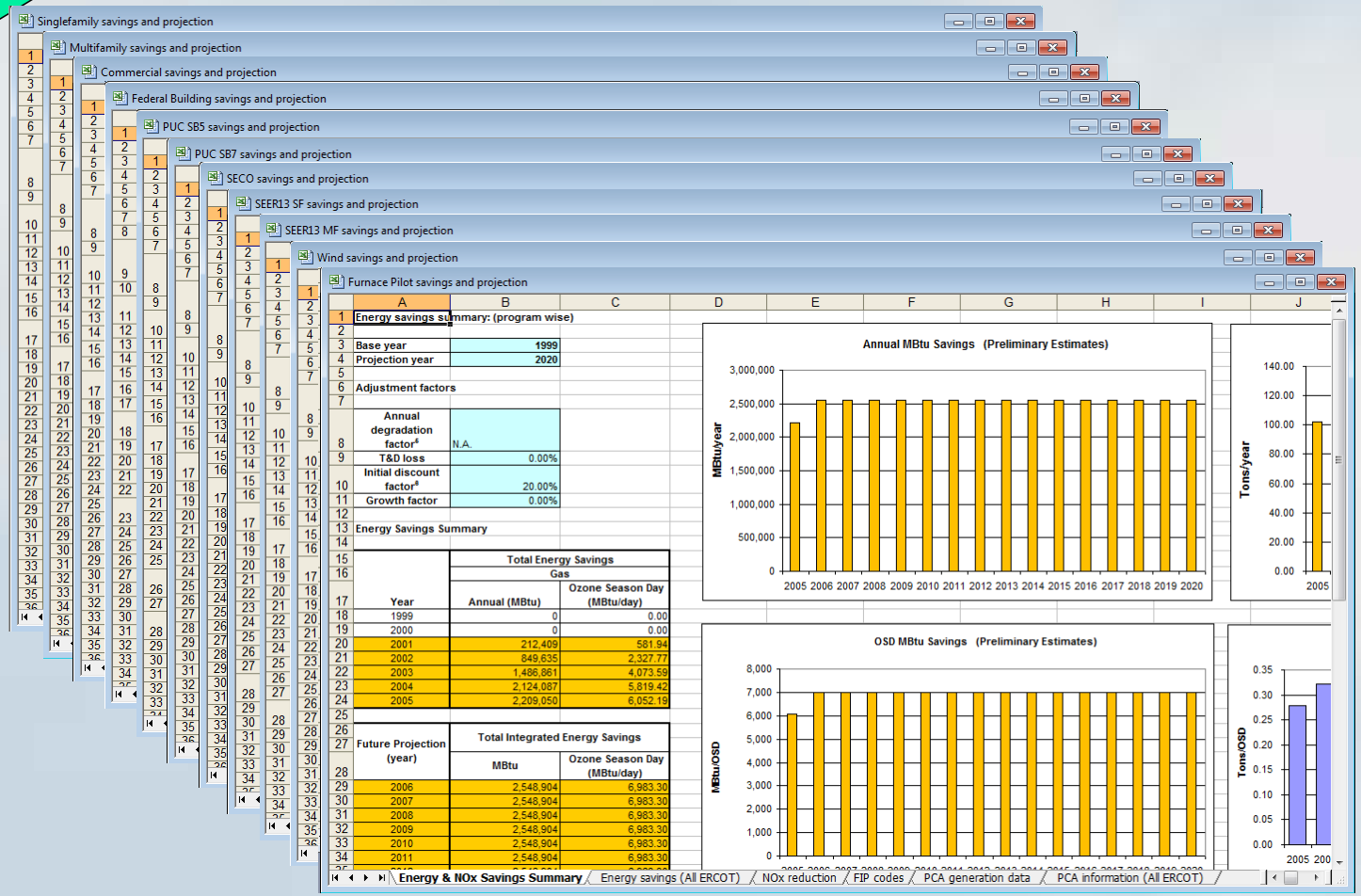
Final Summary Tables For Integrated NOx Reductions & Projections



Wind

INTEGRATED NOx SAVINGS:

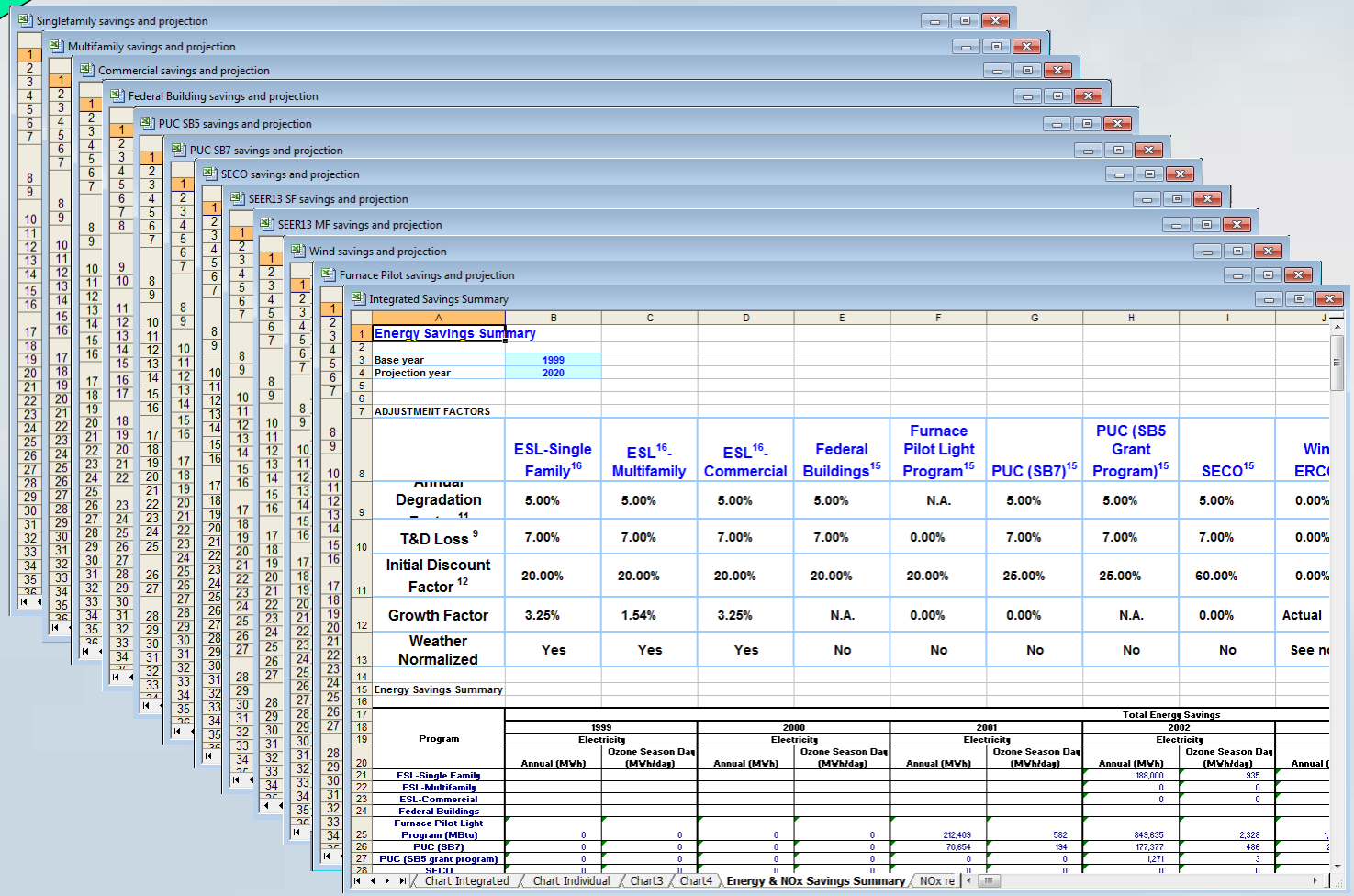
Final Summary Tables For Integrated NOx Reductions & Projections



Furnace Pilot

INTEGRATED NOx SAVINGS:

Final Summary Tables For Integrated NOx Reductions & Projections



Integrated Savings Summary

INTEGRATED NOx SAVINGS – ADJ. FACTORS

	ESL-Single Family[16]	ESL-Multifamily[16]	ESL-Commercial[16]	Federal Buildings[15]	Furnace Pilot Light Program[15]	PUC (SB7)[15]	PUC (SB5 Grant Program)[15]	SECO[15]	Wind-ERCOT[8]	SEER13 Single Family	SEER13 Multifamily
Annual Degradation Factor [11]	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
T&D Loss [9]	7.0%	7.0%	7.0%	7.0%	0.0%	7.0%	7.0%	7.0%	0.0%	7.0%	7.0%
Initial Discount Factor [12]	20%	20%	20%	20%	20%	25%	25%	60%	25%	20%	20%
Growth Factor	3.25%	1.54%	3.25%	0.0%	0.0%	0.0%	0.0%	0.0%	According to SB 20, section 39.904	N.A.	N.A.
Weather Normalized	Yes	Yes	Yes	No	No	No	No	No	See note 7	Yes	Yes

INTEGRATED NOx SAVINGS – ADJ. FACTORS

	ESL-Single Family[16]	ESL-Multifamily[16]	ESL-Commercial[16]	Federal Buildings[15]	Furnace Pilot Light Program[15]	PUC (SB7)[15]	PUC (SB5 Grant Program)[15]	SECO[15]	Wind-ERCOT[8]	SEER13 Single Family	SEER13 Multifamily
Annual Degradation Factor [11]	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
T&D Loss [9]	7.0%	7.0%	7.0%	7.0%	0.0%	7.0%	7.0%	7.0%	0.0%	7.0%	7.0%
Initial Discount Factor [12]	20%	20%	20%	20%	20%	25%	25%	60%	25%	20%	20%
Growth Factor	3.25%	1.54%	3.25%	0.0%	0.0%	0.0%	0.0%	0.0%	According to SB 20, section 39.904	N.A.	N.A.
Weather Normalized	Yes	Yes	Yes	No	No	No	No	No	See note 7	Yes	Yes

(11) The 5% annual degradation factor for all programs has been taken from Kats, G.H. et al. (1996) "Energy Efficiency as a Commodity," ACEEE.

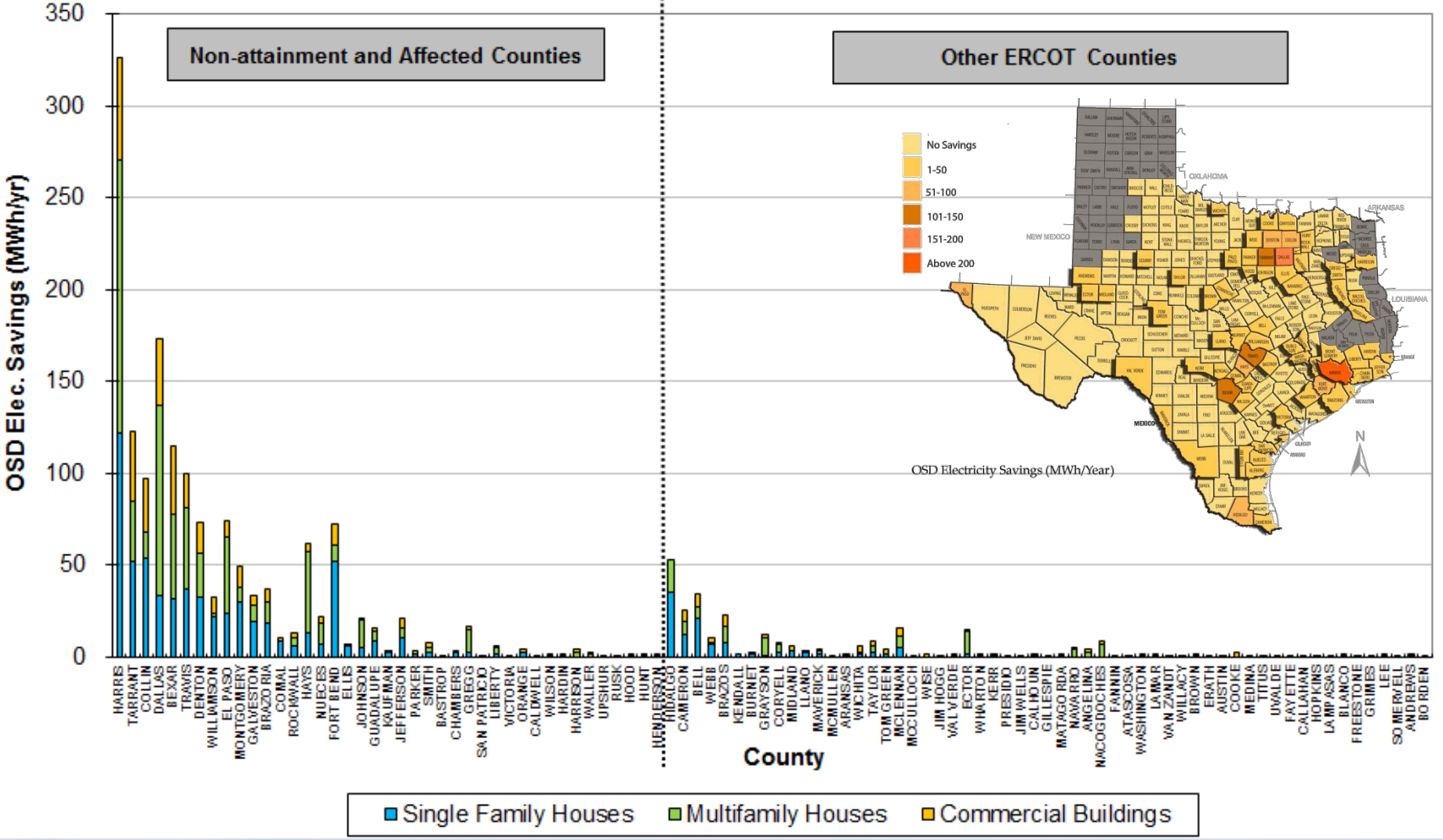
(9) T&D losses are 7% except for Wind-ERCOT are 0.00% or negative since Wind is displacing the power produced by conventional plants which already have a T&D Loss associated with them.

(12) The initial discount factor for each program should be chosen to reflect the accuracy of the reported numbers.

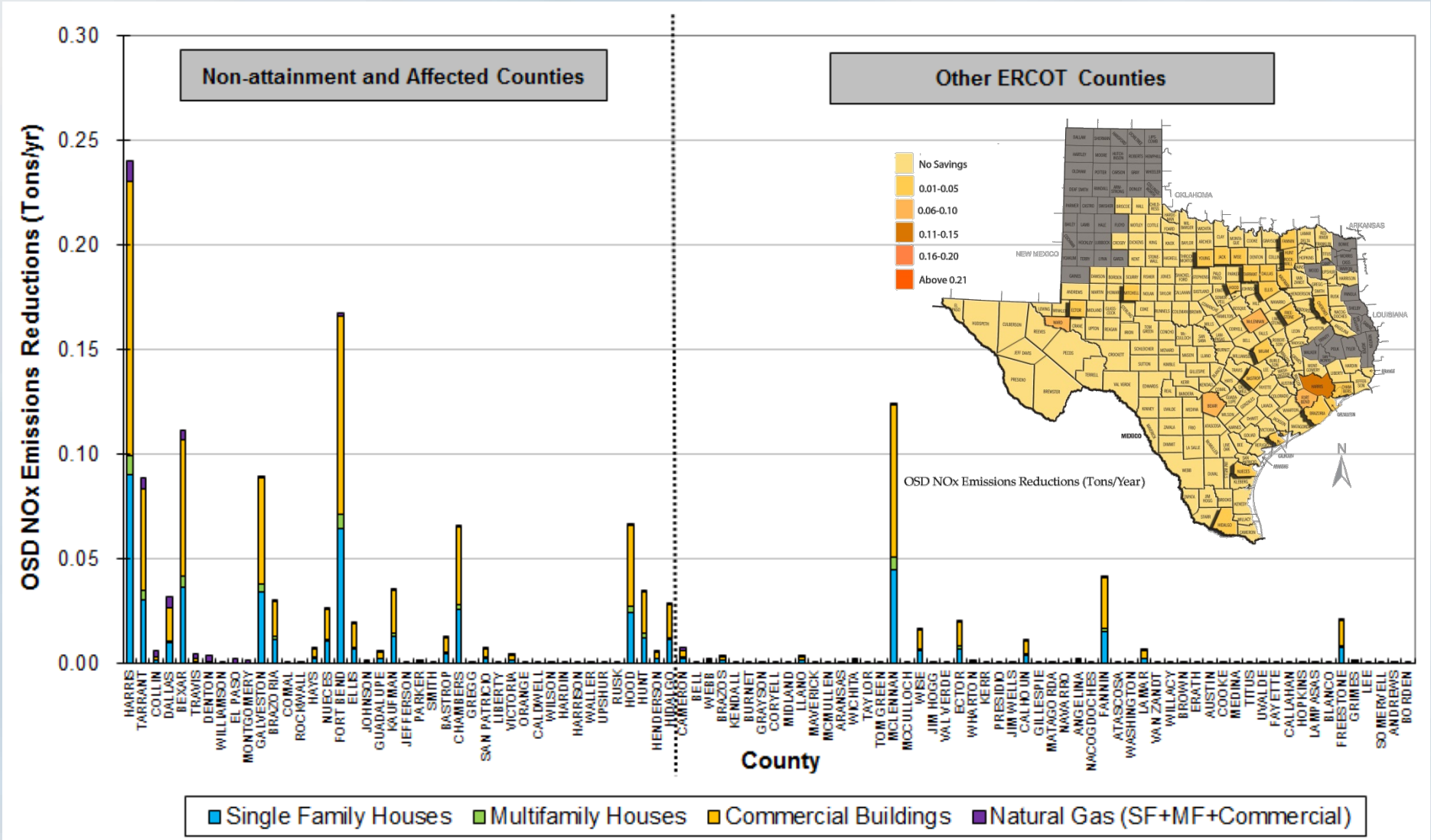
(16) Growth factors for single-family (3.25%) and multi-family residential (1.54%) construction values represent the average growth rate for these housing types from the U.S. Census data for Texas

(15) The growth factor for Federal Buildings, Furnace pilot lights, PUC(SB7), PUC(SB5) and SECO is 0%, since it is being assumed that the future year savings will be at the same level as 2005.

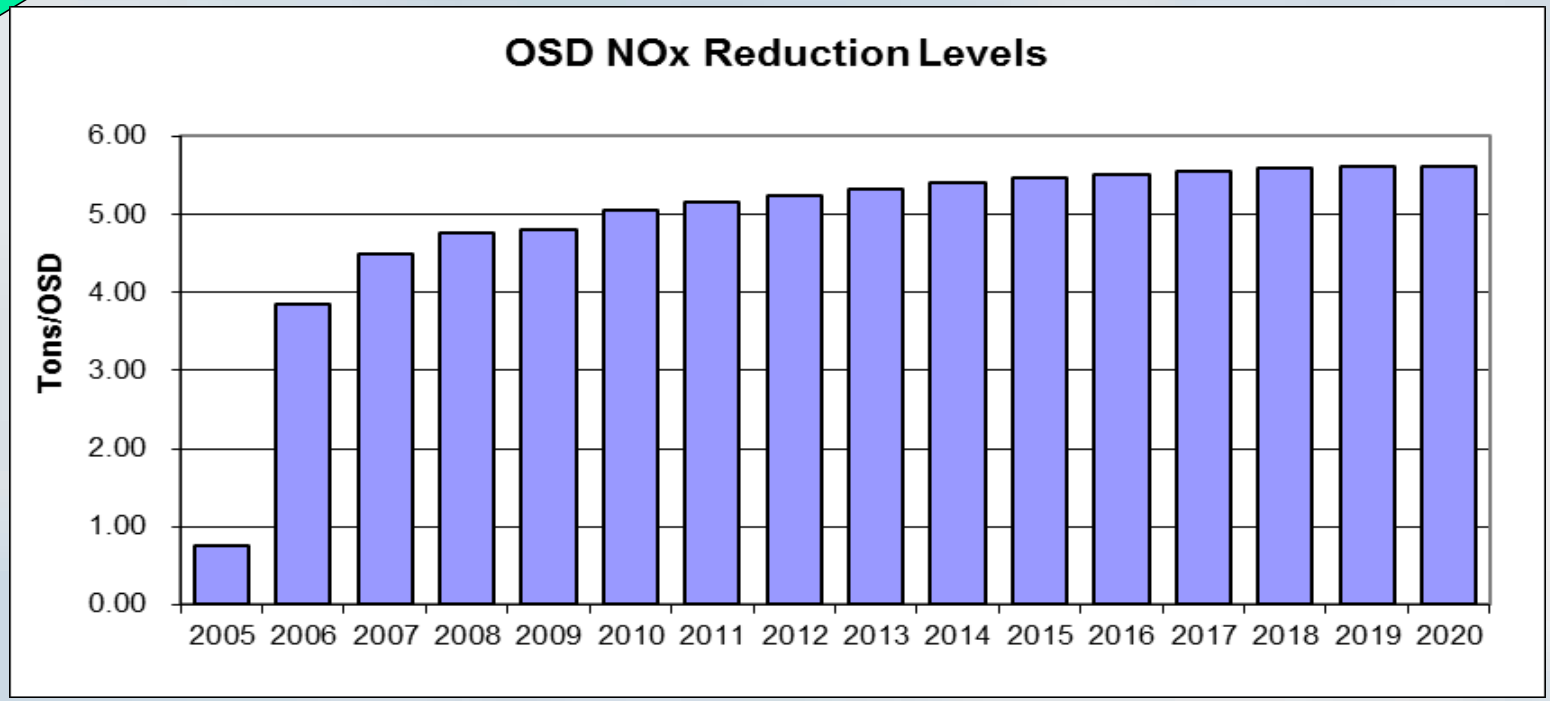
INTEGRATED NOx SAVINGS:
Result of OSD Electricity Savings



INTEGRATED NOx SAVINGS:
Result of OSD NOx Emissions Reductions



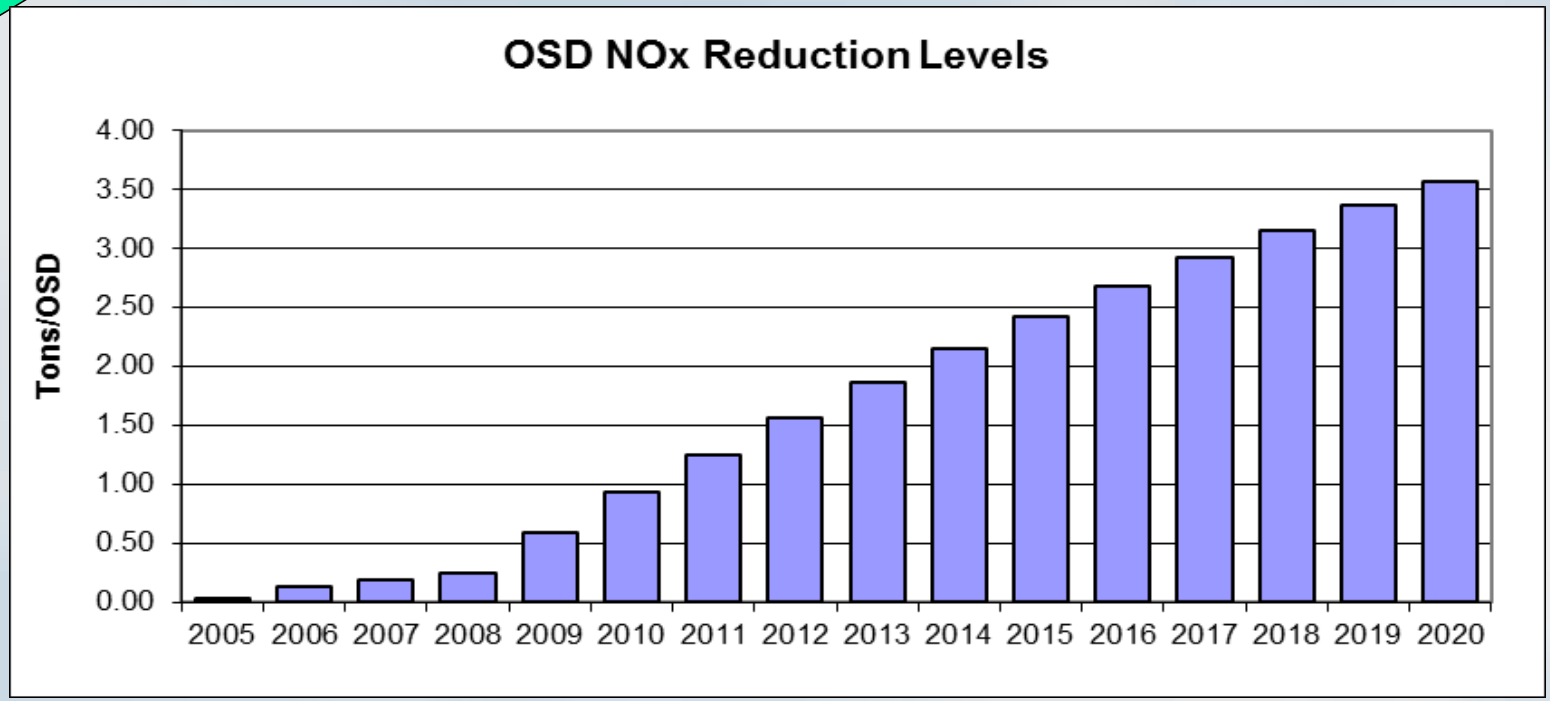
INTEGRATED NOx SAVINGS:
Single Family Savings and Projection



CUMULATIVE NOx EMISSIONS SAVINGS (2013)

– ESL Code Compliance	(9.03 tons/day)	(26.3%)
– Federal Buildings	(0.81 tons/day)	(1.9%)
– Furnace Pilot Lights	(0.32 tons/day)	(0.8%)
– PUCs SB7,SB5 programs	(5.78 tons/day)	(11.7%)
– SECO Political Sub.	(1.01 tons/day)	(2.0%)
– Green Power (Wind)	(32.63 tons/day)	(30.1%)
– SEER 13 Retrofits	(11.03 tons/day)	(26.9%)
Total	**(60.61 tons/day)**	**(100.0%)**

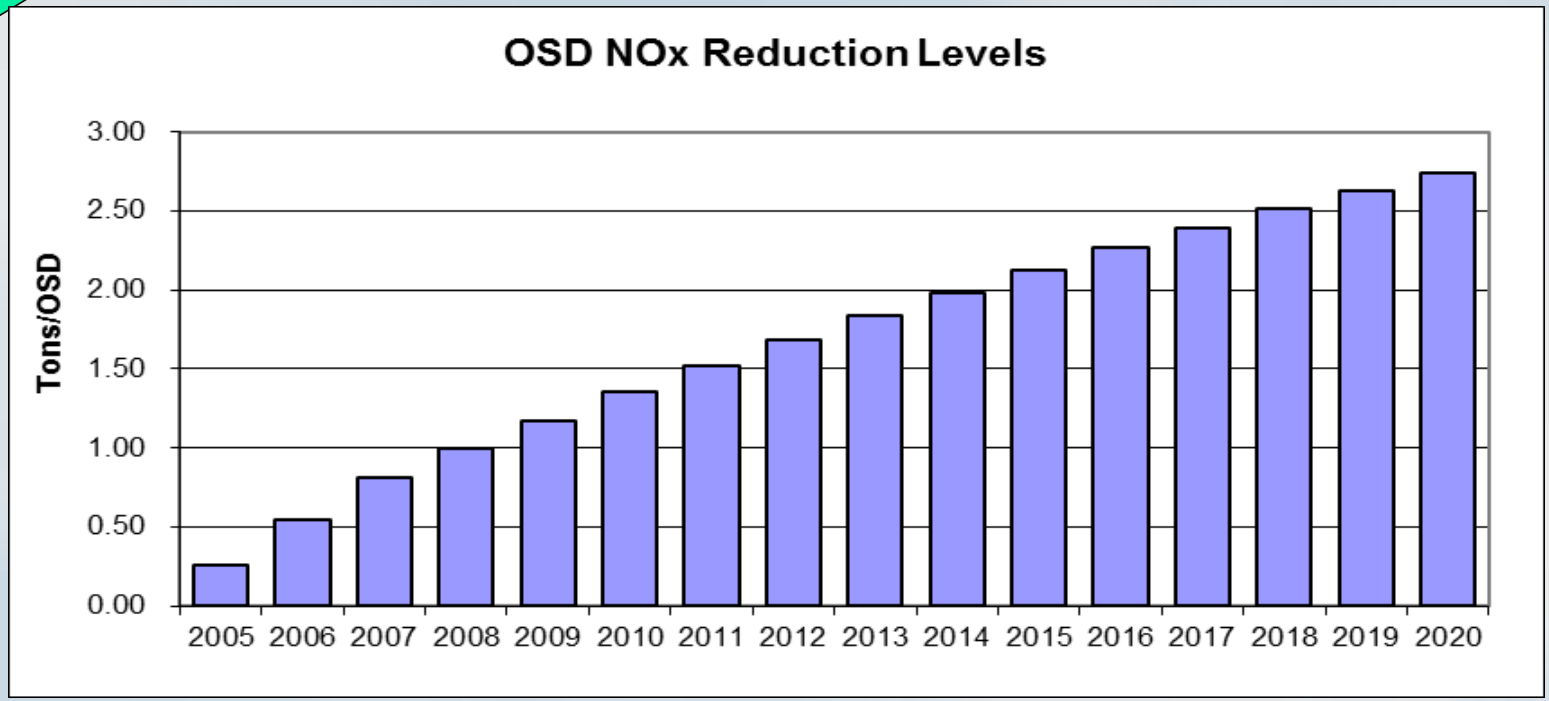
INTEGRATED NOx SAVINGS:
Multi-Family Savings and Projection



CUMULATIVE NOx EMISSIONS SAVINGS (2013)

–	ESL Code Compliance	(9.03 tons/day)	(26.3%)
–	Federal Buildings	(0.81 tons/day)	(1.9%)
–	Furnace Pilot Lights	(0.32 tons/day)	(0.8%)
–	PUCs SB7,SB5 programs	(5.78 tons/day)	(11.7%)
–	SECO Political Sub.	(1.01 tons/day)	(2.0%)
–	Green Power (Wind)	(32.63 tons/day)	(30.1%)
–	SEER 13 Retrofits	(11.03 tons/day)	(26.9%)
	Total	**(60.61 tons/day)**	**(100.0%)**

INTEGRATED NOx SAVINGS:
Commercial Savings and Projection

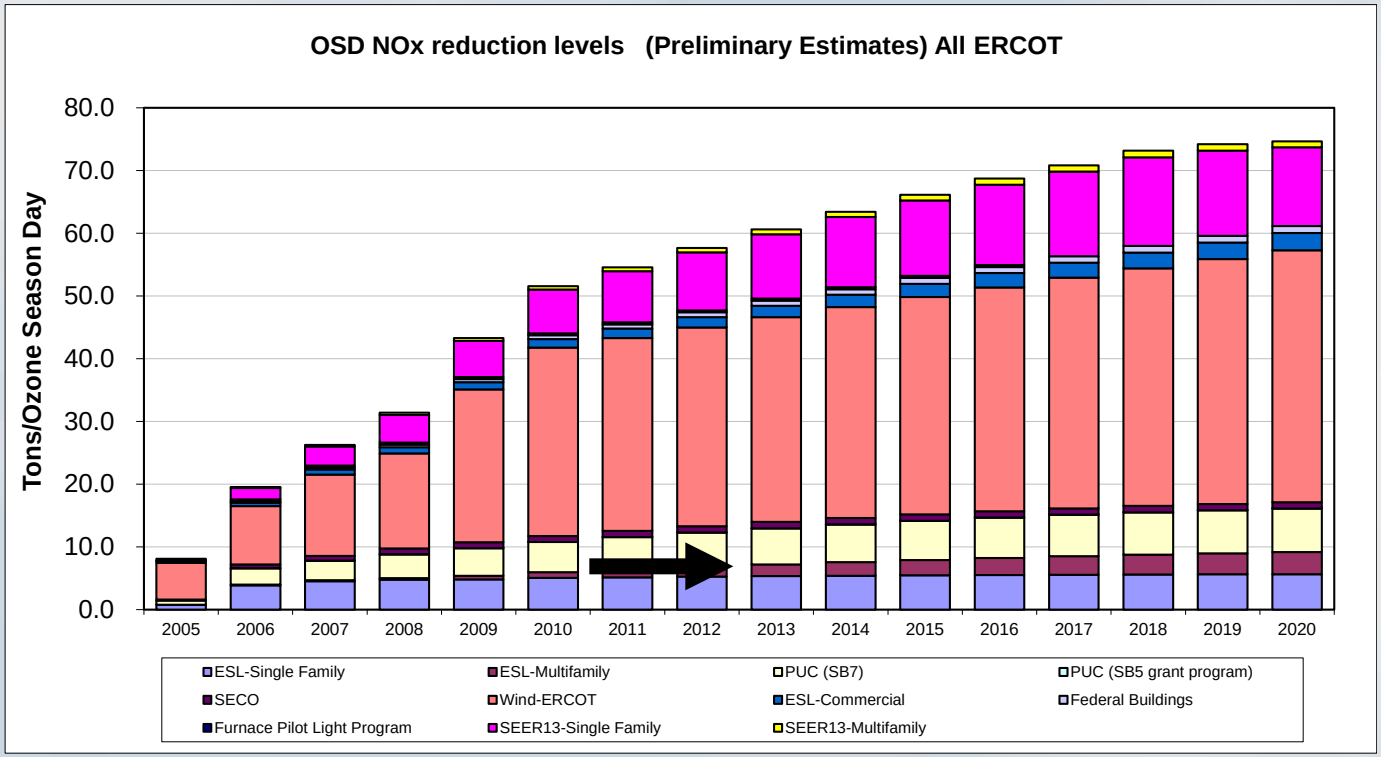


CUMULATIVE NOx EMISSIONS SAVINGS (2013)

– ESL Code Compliance	(9.03 tons/day)	(26.3%)
– Federal Buildings	(0.81 tons/day)	(1.9%)
– Furnace Pilot Lights	(0.32 tons/day)	(0.8%)
– PUCs SB7,SB5 programs	(5.78 tons/day)	(11.7%)
– SECO Political Sub.	(1.01 tons/day)	(2.0%)
– Green Power (Wind)	(32.63 tons/day)	(30.1%)
– SEER 13 Retrofits	(11.03 tons/day)	(26.9%)
Total	**(60.61 tons/day)**	**(100.0%)**

INTEGRATED NOx SAVINGS

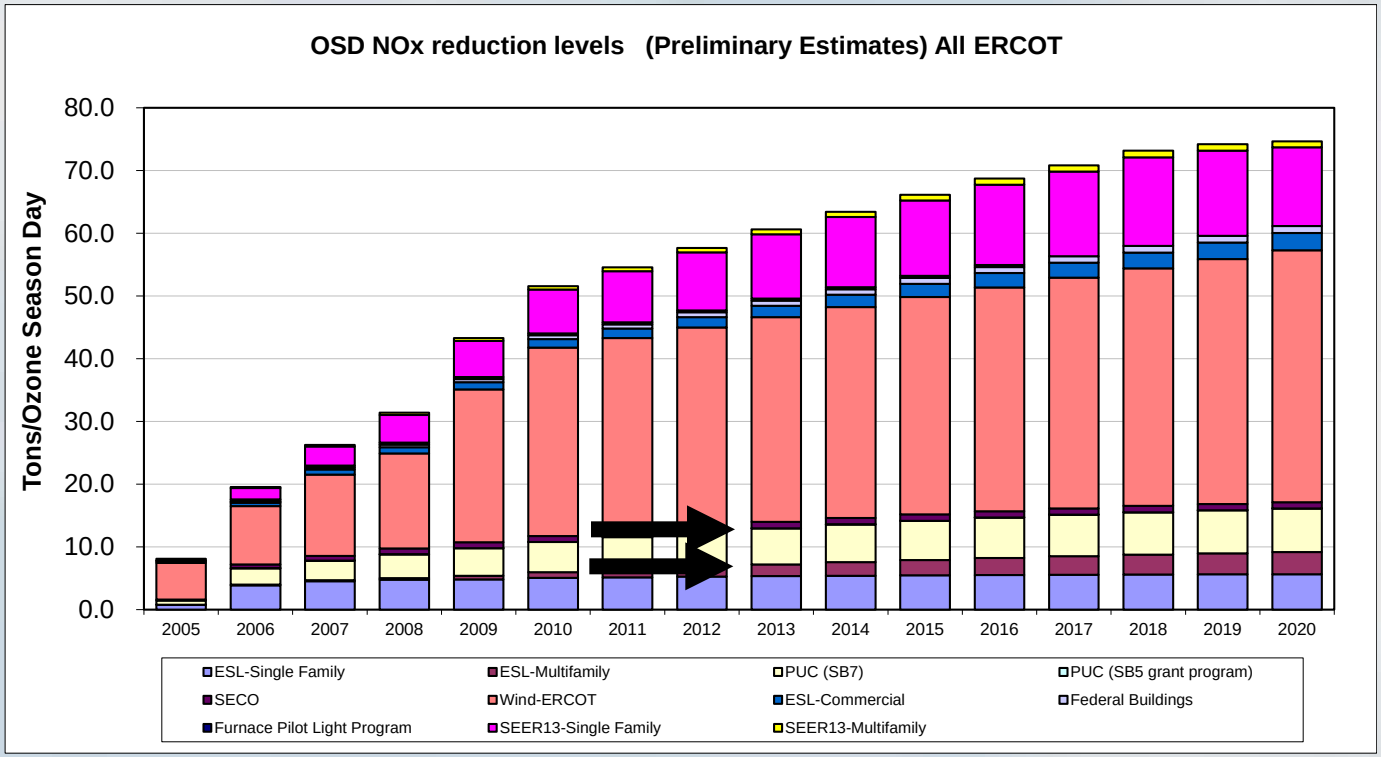
2010 Integrated Emissions Savings (2013)



ESL Code Compliance (9.03 tons/day)

INTEGRATED NOx SAVINGS

2010 Integrated Emissions Savings (2013)

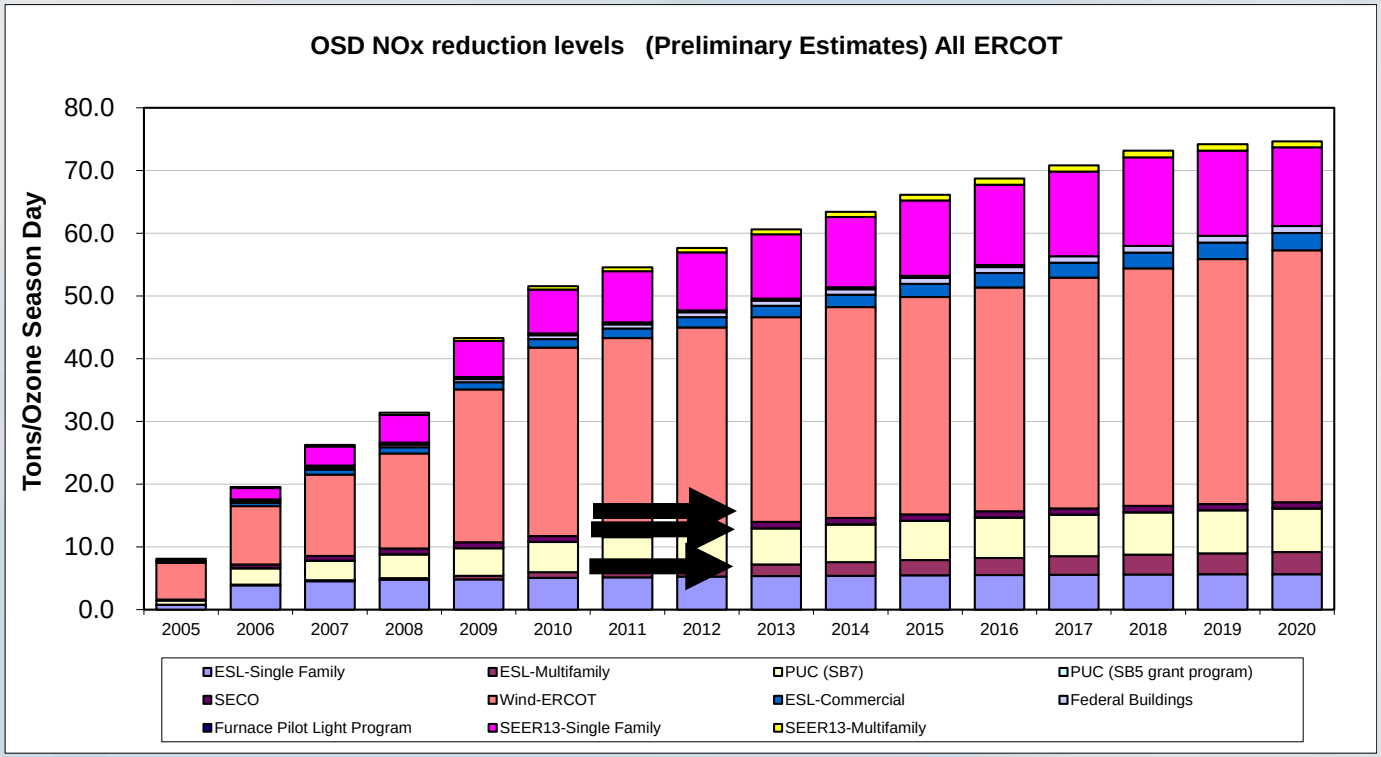


ESL Code Compliance (9.03 tons/day)

PUC SB5,SB7 programs (5.78 tons/day)

INTEGRATED NOx SAVINGS

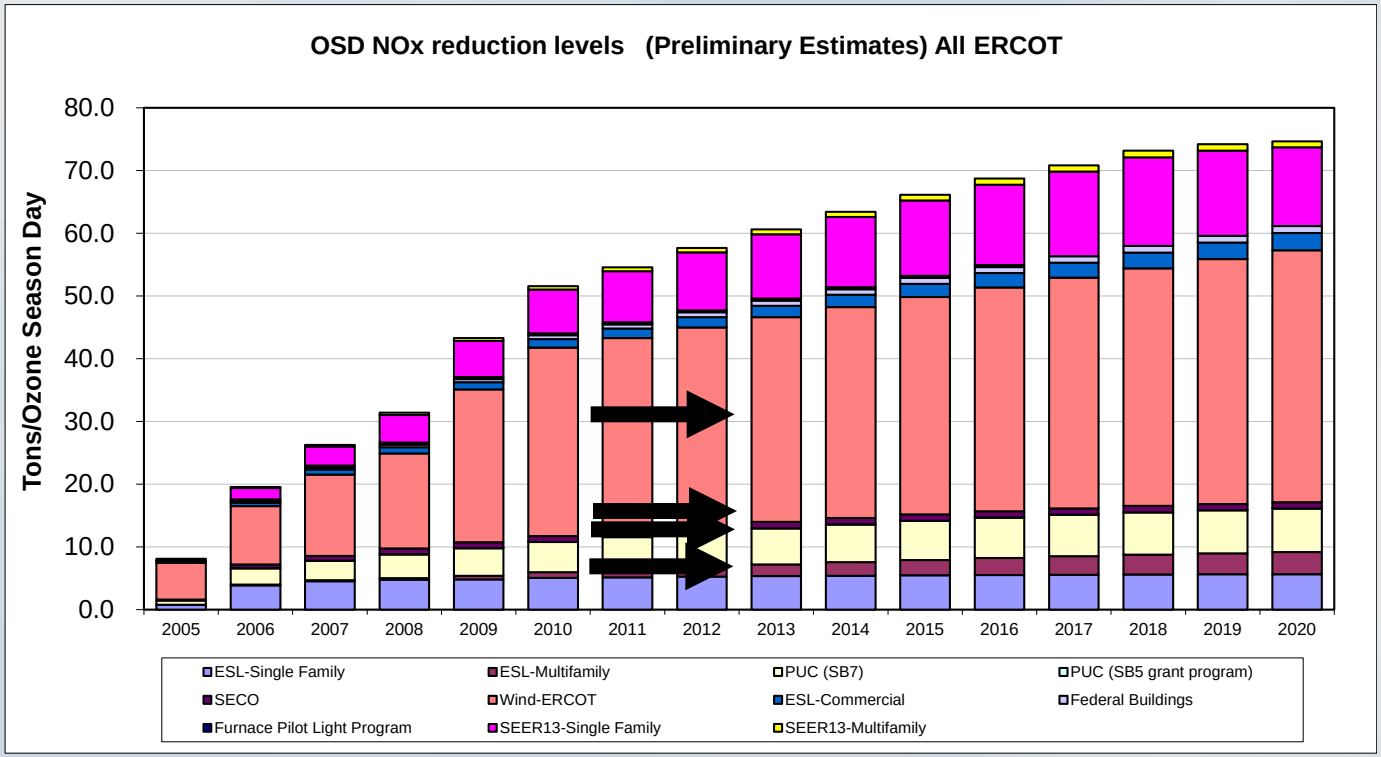
2010 Integrated Emissions Savings (2013)



ESL Code Compliance (9.03 tons/day)
PUC SB5,SB7 programs (5.78 tons/day)
SECO Political Sub. (1.01 tons/day)

INTEGRATED NOx SAVINGS

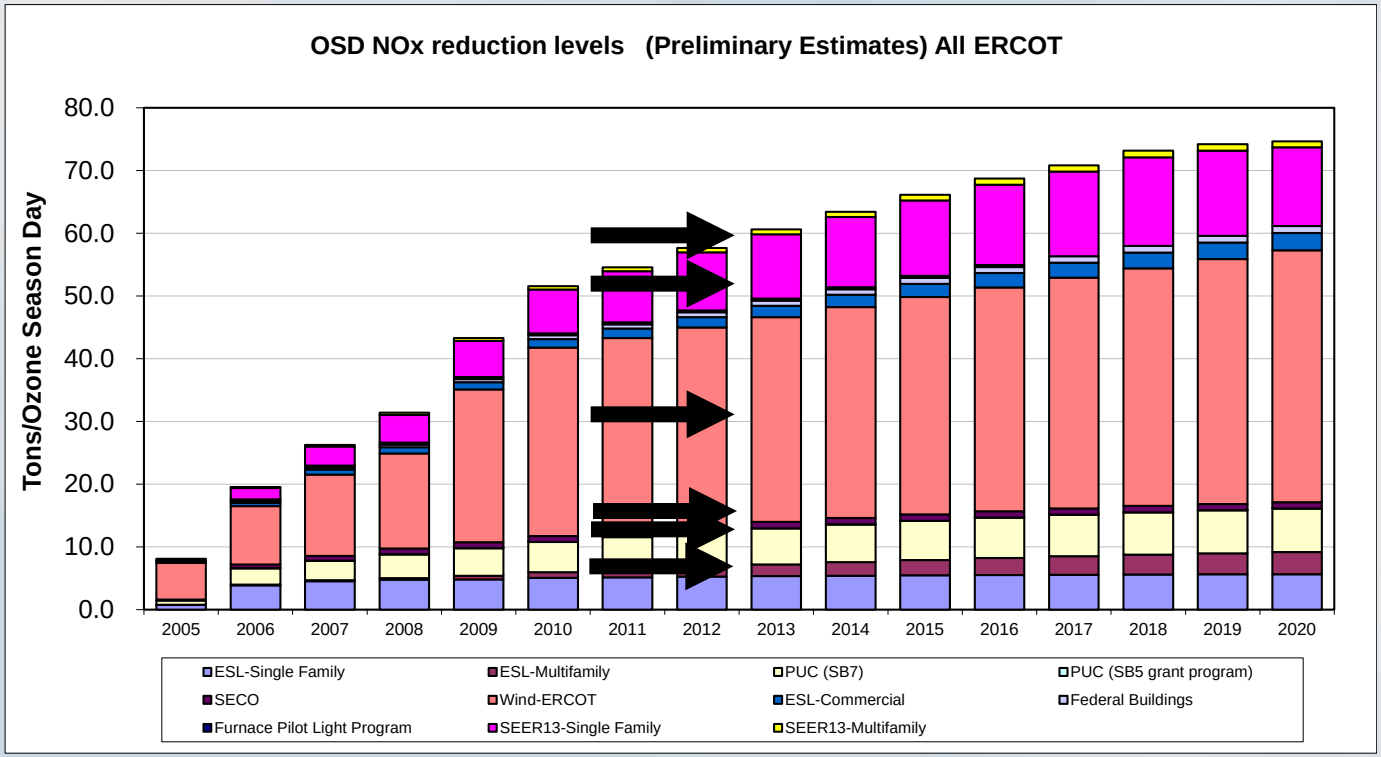
2010 Integrated Emissions Savings (2013)



ESL Code Compliance (9.03 tons/day)
PUC SB5,SB7 programs (5.78 tons/day)
SECO Political Sub. (1.01 tons/day)
Green Power (Wind) (32.63 tons/day)

INTEGRATED NOx SAVINGS

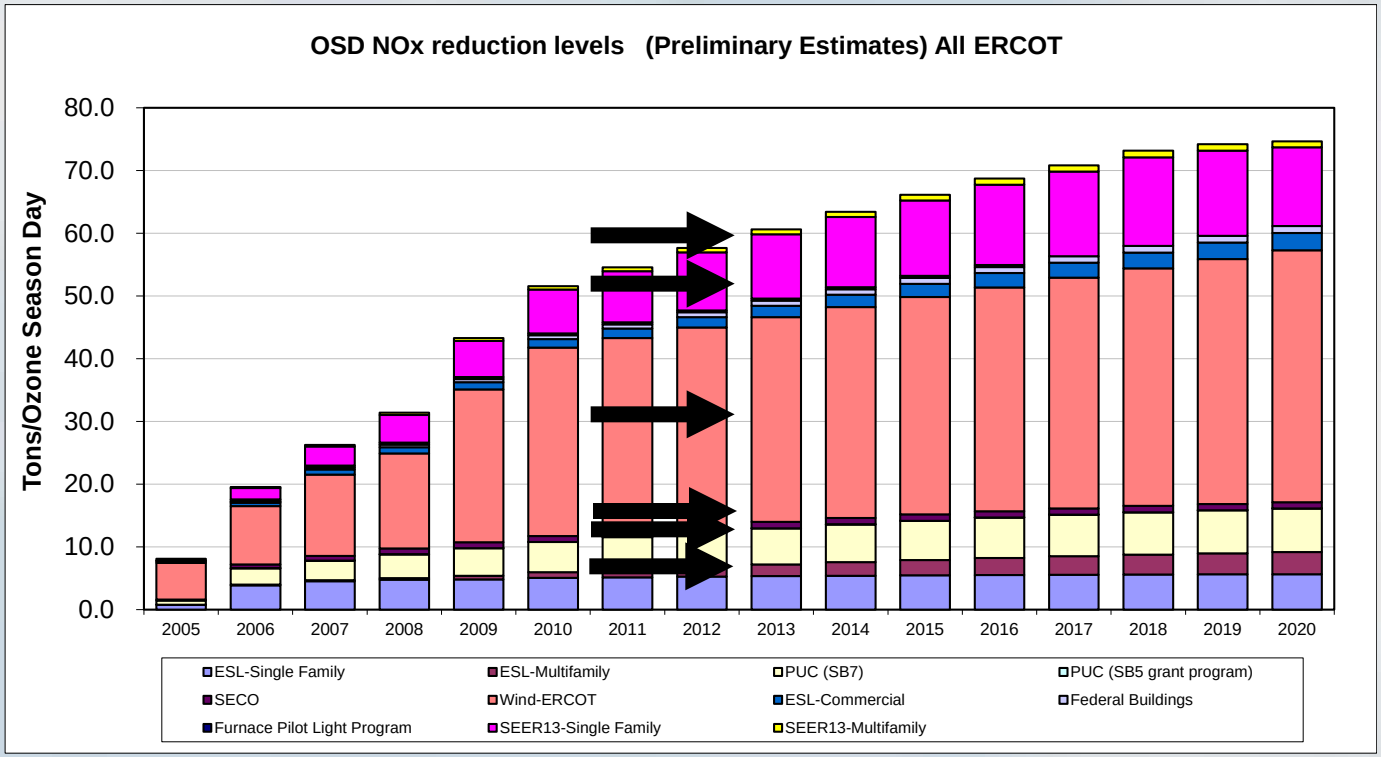
2010 Integrated Emissions Savings (2013)



ESL Code Compliance (9.03 tons/day)
PUC SB5,SB7 programs (5.78 tons/day)
SECO Political Sub. (1.01 tons/day)
Green Power (Wind) (32.63 tons/day)
Residential AC Retrofits (11.03 tons/day)

INTEGRATED NOx SAVINGS

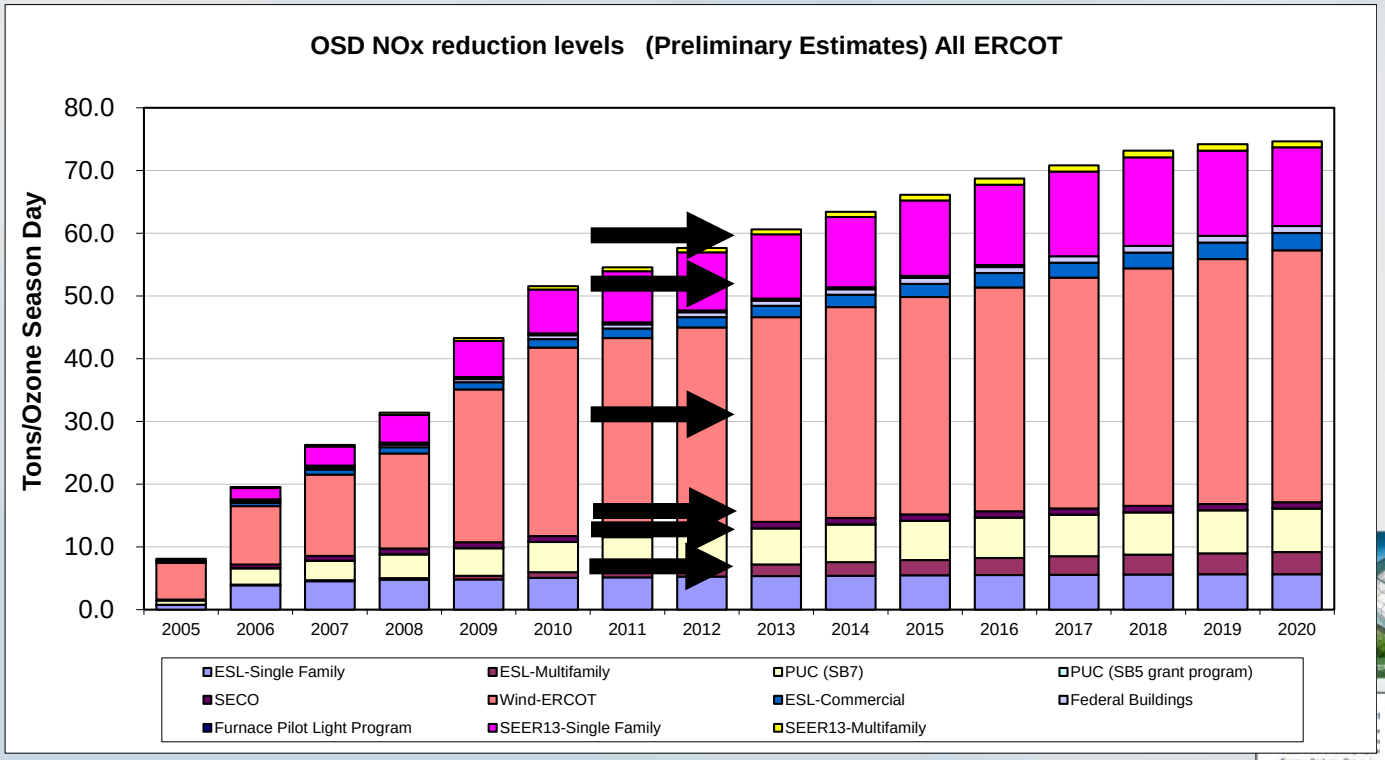
2010 Integrated Emissions Savings (2013)



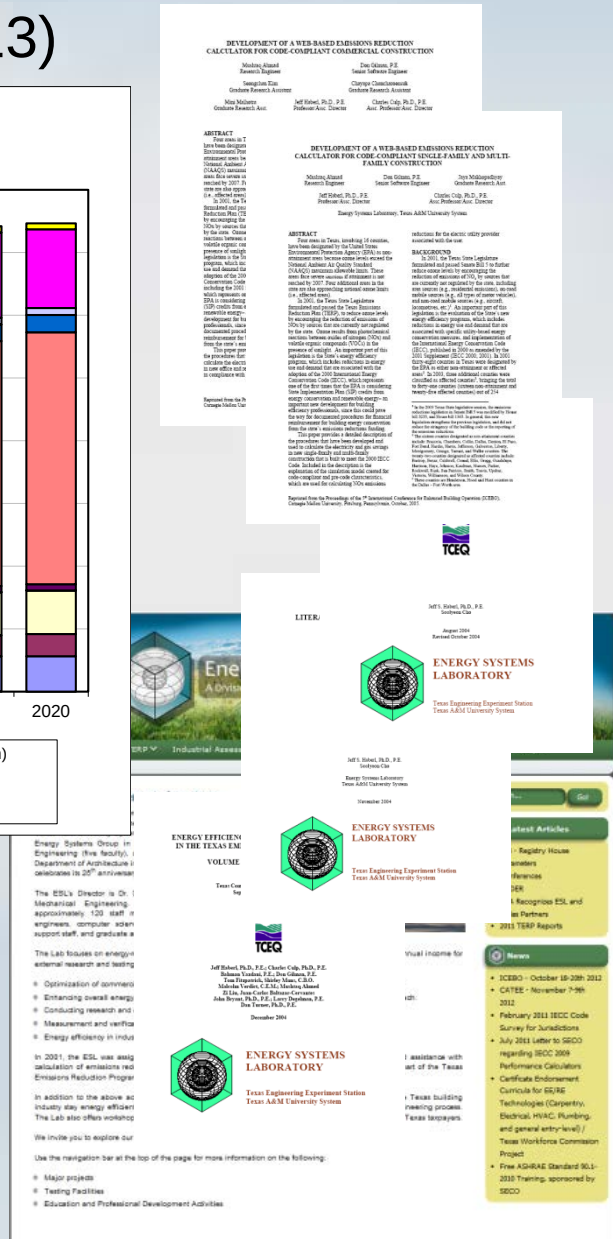
ESL Code Compliance	(9.03 tons/day)
PUC SB5,SB7 programs	(5.78 tons/day)
SECO Political Sub.	(1.01 tons/day)
Green Power (Wind)	(32.63 tons/day)
Residential AC Retrofits	(11.03 tons/day)
Total	**(60.61 tons/day)**

INTEGRATED NOx SAVINGS

2010 Integrated Emissions Savings (2013)



ESL Code Compliance	(9.03 tons/day)
PUC SB5,SB7 programs	(5.78 tons/day)
SECO Political Sub.	(1.01 tons/day)
Green Power (Wind)	(32.63 tons/day)
Residential AC Retrofits	(11.03 tons/day)
Total	**(60.61 tons/day)**



ANNUAL CONFERENCE

CATEE
Clean Air Through Energy Efficiency Conference

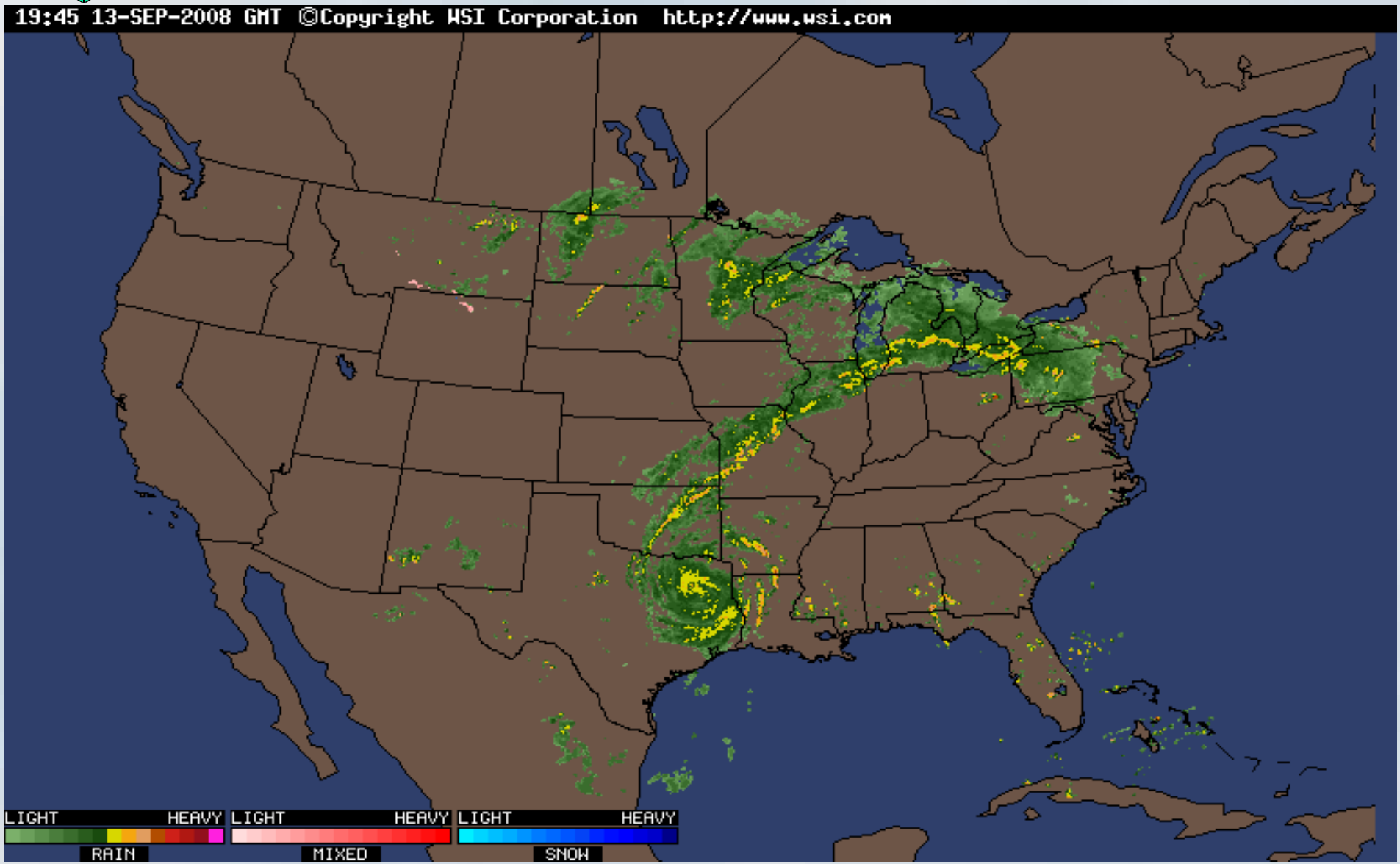
The CATEE Conference (originally called the Air Quality Energy Leadership and Emissions Reduction Conference) started in 2004 and has been held every year throughout the State of Texas.

2004 – San Antonio
2005 – Dallas
2006 – Houston
2007 – San Antonio
2008 – Plano
2009 – Houston
2010 – Austin
2011 – Dallas
2012 – Galveston

For more information, please visit the website: **http://catee.tamu.edu**

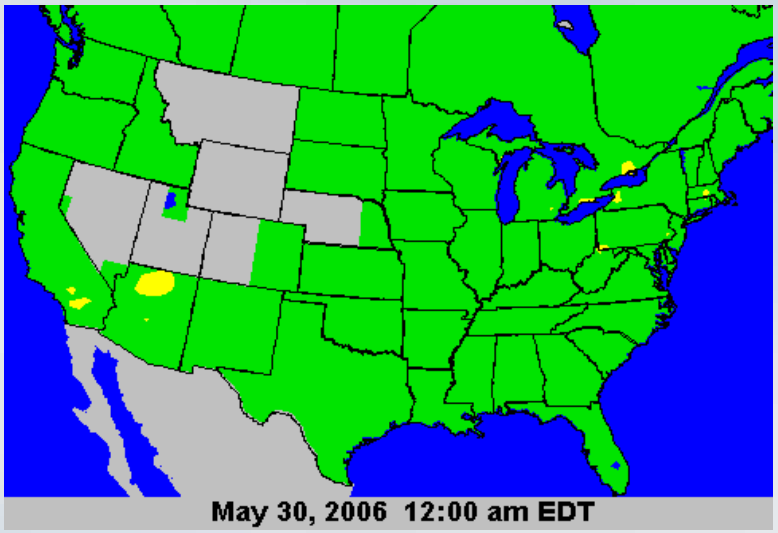
FUTURE: IMPROVED WIND PREDICTIONS

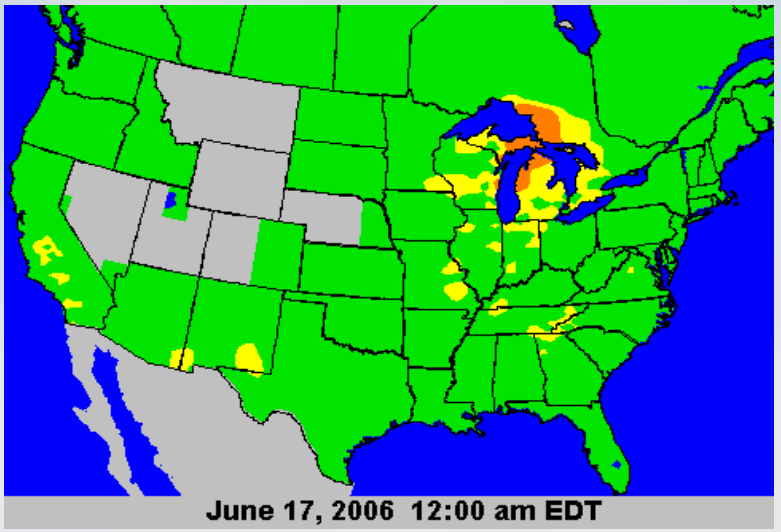
Improve Base-year Wind Modeling using met. models

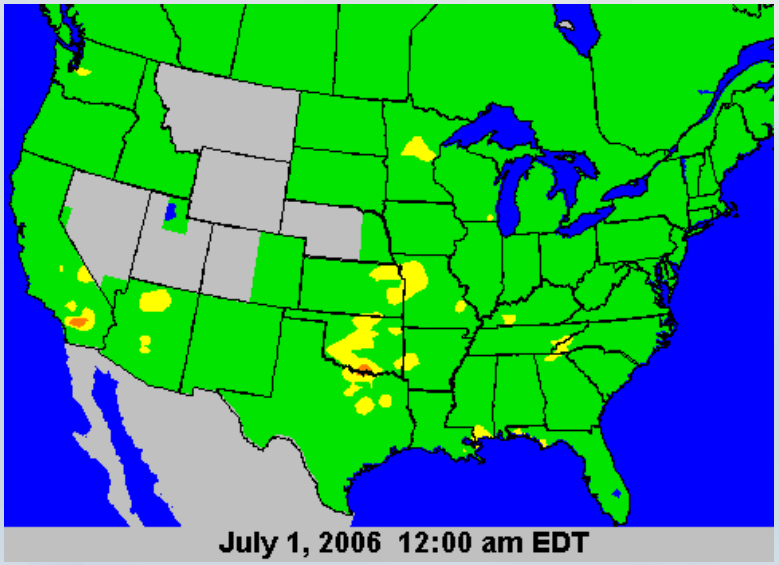


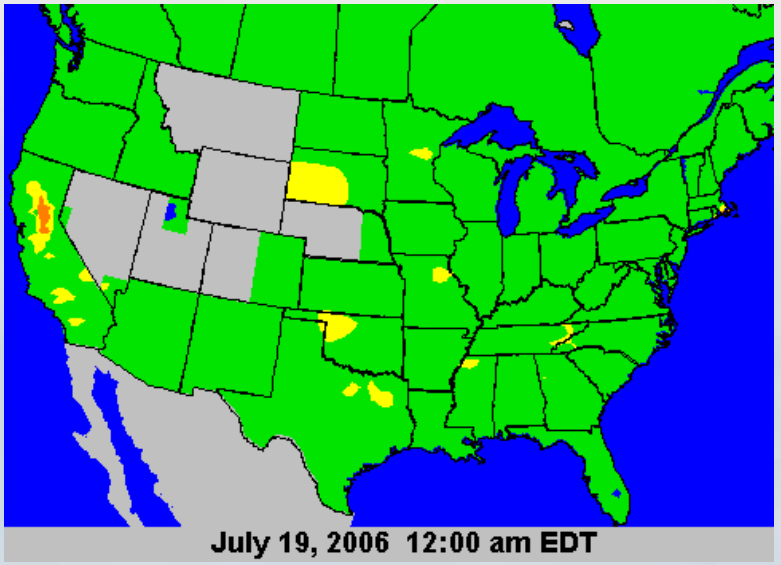
FUTURE WORK: HELPING OTHER STATES

Extend Modeling Procedures to Other States/Regions









FUTURE: COMPACT FLUORESCENT LAMPS

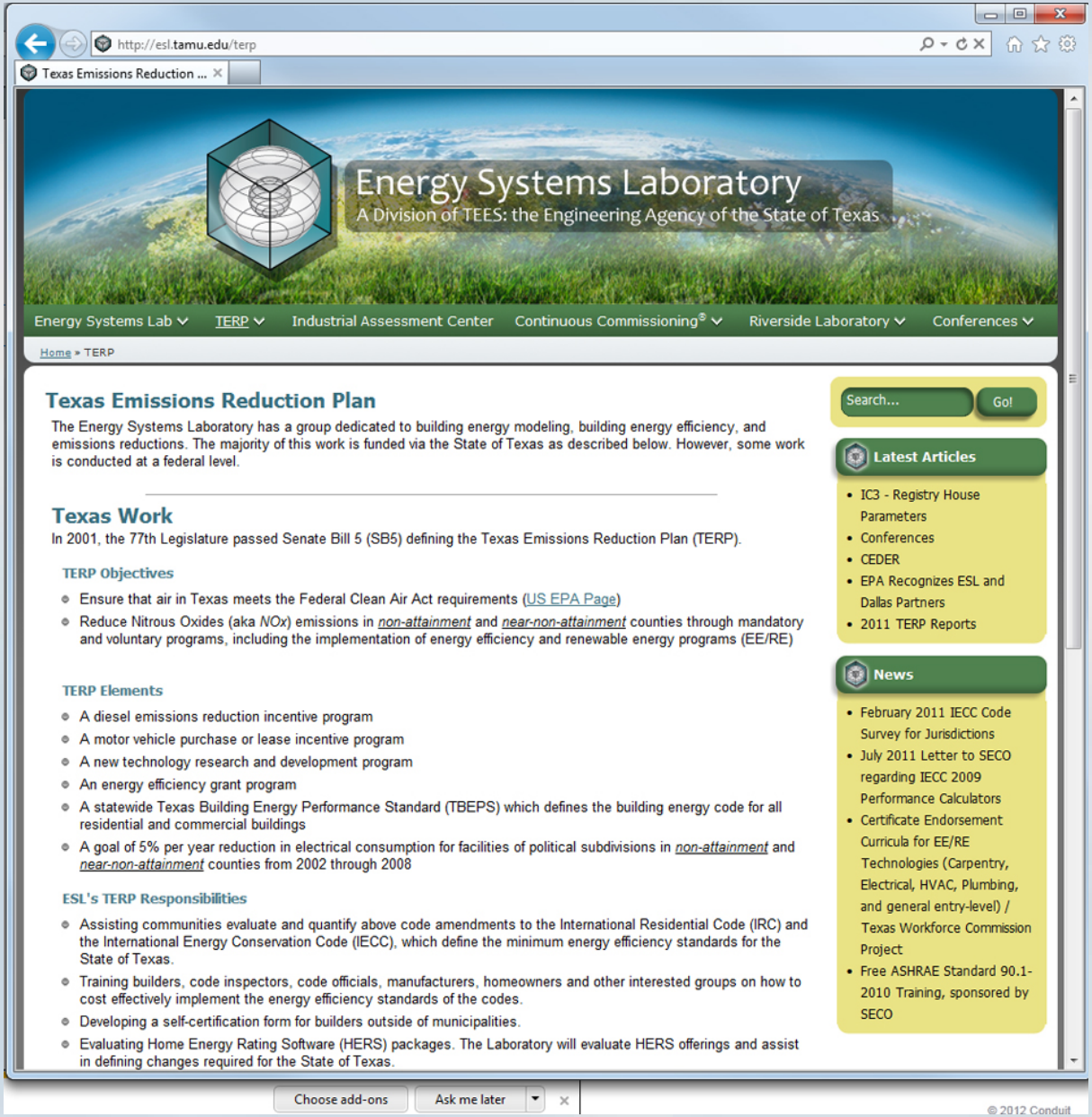
= NOx reductions?

FUTURE: COMPACT FLUORESCENT LAMPS

= NOx reductions?

Impact of 2012 Federal legislation to phase-out incandescent lamps expected to be significant.

WEBSITE


http://esl.tamu.edu/terp
Texas Emissions Reduction ...
Energy Systems Laboratory
A Division of TEES: the Engineering Agency of the State of Texas
Energy Systems Lab
TERP
Industrial Assessment Center
Continuous Commissioning®
Riverside Laboratory
Conferences
Home » TERP
Texas Emissions Reduction Plan
The Energy Systems Laboratory has a group dedicated to building energy modeling, building energy efficiency, and emissions reductions. The majority of this work is funded via the State of Texas as described below. However, some work is conducted at a federal level.
Texas Work
In 2001, the 77th Legislature passed Senate Bill 5 (SB5) defining the Texas Emissions Reduction Plan (TERP).
TERP Objectives
Ensure that air in Texas meets the Federal Clean Air Act requirements (US EPA Page)
Reduce Nitrous Oxides (aka NOx) emissions in non-attainment and near-non-attainment counties through mandatory and voluntary programs, including the implementation of energy efficiency and renewable energy programs (EE/RE)
TERP Elements
A diesel emissions reduction incentive program
A motor vehicle purchase or lease incentive program
A new technology research and development program
An energy efficiency grant program
A statewide Texas Building Energy Performance Standard (TBEPS) which defines the building energy code for all residential and commercial buildings
A goal of 5% per year reduction in electrical consumption for facilities of political subdivisions in non-attainment and near-non-attainment counties from 2002 through 2008
ESL's TERP Responsibilities
Assisting communities evaluate and quantify above code amendments to the International Residential Code (IRC) and the International Energy Conservation Code (IECC), which define the minimum energy efficiency standards for the State of Texas.
Training builders, code inspectors, code officials, manufacturers, homeowners and other interested groups on how to cost effectively implement the energy efficiency standards of the codes.
Developing a self-certification form for builders outside of municipalities.
Evaluating Home Energy Rating Software (HERS) packages. The Laboratory will evaluate HERS offerings and assist in defining changes required for the State of Texas.
Search...
Go!
Latest Articles
IC3 - Registry House Parameters
Conferences
CEDER
EPA Recognizes ESL and Dallas Partners
2011 TERP Reports
News
February 2011 IECC Code Survey for Jurisdictions
July 2011 Letter to SECO regarding IECC 2009 Performance Calculators
Certificate Endorsement Curricula for EE/RE Technologies (Carpentry, Electrical, HVAC, Plumbing, and general entry-level) / Texas Workforce Commission Project
Free ASHRAE Standard 90.1-2010 Training, sponsored by SECO
Choose add-ons
Ask me later
© 2012 Conduit

ESL Contact Information

Jeff Haberl: jeffhaberl@tees.tamus.edu

http://eslsb5.tamu.edu